University of Alberta
Printing Department

THE UNIVERSITY OF ALBERTA

THE ECOLOGY OF MOUNTAIN GOATS IN WEST CENTRAL ALBERTA

by

GORDON ROBERT KERR

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF ZOOLOGY

EDMONTON, ALBERTA

APRIL 1965

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled THE ECOLOGY OF MOUNTAIN GOATS IN WEST CENTRAL ALBERTA submitted by Gordon Robert Kerr in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The general ecology of mountain goats was studied on two areas in west central Alberta.

Body weights and measurements of all goats examined were recorded. Age determination techniques involving annual horn rings, horn length, weights and teeth were investigated. Several other physical charac - teristics were also studied.

Daily movements and activities as well as seasonal groupings, movements and distribution were investigated. The lowest average herd size was during the parturition period in May while the highest average herd size occurred in late winter. Factors affecting movements, grouping and distribution are discussed.

A study of food habits constituted a large portion of the investi - gation. Shrubs and alpine fir were found to be the primary winter foods. Several other aspects of range and food habits were investigated. The four major factors found to determine the location of winter range were: south or southwest facing exposures, ridges free of snow or with a reduced snow cover, escape terrain in the form of cliffs immediately adjacent to and available to the ridges and the presence of shrubs and/or coniferous trees.

Reproduction and variations in productivity were studied over a 3 year period. Sexual maturity was reached at 2½ years of age. Twinning did not occur or was at least rare. The influence on reproduction of weather and sex ratios during the winter are discussed.

Ten mountain goats were autopsied for the presence of diseases and

parasites. Lumpjaw or actinomycosis in one individual and possible verminous pneumonia in two others were the only obvious disease conditions found. Two species of ticks and 11 helminths were identified.

The importance of natural hazards, predation and malnutrition as well as the effects of hunting and accessibility of goat habitat to hunters were investigated. Winter in general was found to be the primary enemy of mountain goat populations since it is at this time that they are most susceptible to malnutrition, parasites, diseases, predation and natural hazards.

ACKNOWLEDGMENTS

I am very grateful to the Alberta Department of Lands and Forests, Fish and Wildlife Division for supplying equipment and allowing me time necessary for collecting data and the writing of this manuscript.

I should like to express special thanks to John G. Stelfox, Wildlife Biologist, for his generous aid and suggestions in data collecting as well as proof reading this paper.

I am indebted to Dr. W. A. Fuller and Dr. J. C. Holmes, University of Alberta, for their help in planning and organizing this entire investigation as well as providing helpful suggestions upon reading the manuscript.

Appreciation is extended to my father, James R. Kerr, for placing a "Burro" at my disposal throughout the study.

Appreciation is also extended to Dr. W. W. Becklund, Acting Leader, Parasite Classification and Distribution Investigations, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md., and Dr. J. C. Holmes for their identification of helminthological materials.

Mr. A. Oeming was helpful in supplying information on captive goats and in allowing the securing of information from them. Messrs. Giest, Department of Zoology, University of British Columbia, and Holroyd, Park Warden, Banff National Park, were also helpful in making their personal observations available to me.

I should like to thank my wife for her efforts in typing and proof reading this manuscript as well as encouraging me throughout the study.

Mr. W. Wishart, Wildlife Biologist, provided valuable suggestions

which greatly improved this paper.

I should like to thank the field personnel of the United States Steel Company as well as forest officers M. Davis and A. Miller for the hospitality and friendship shown towards me while working with them.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The main purpose of my study was to investigate the general ecology of mountain goats (Oreamnos americanus americanus), with hopes that sufficient new knowledge would be gained to allow improved management of the populations.

To my knowledge the ecology of mountain goats is a subject here - tofore uninvestigated in the Province of Alberta. Mountain goat investigations have been carried out previously in British Columbia but these have generally been very limited in scope or done in con - junction with general big game investigations in which other species have been given priority.

Several extensive studies have been undertaken in the northwestern United States as well as in the state of Alaska. These studies however have involved different subspecies of goats than those which inhabit most of the mountain goat range of Alberta and were conducted under considerably different environmental conditions.

Disagreement amongst investigators over such things as winter food habits, minimum breeding age and mortality or factors regulating population numbers coupled with the lack of knowledge of parasites, diseases and physical characteristics of Alberta mountain goats, prompted me to pursue this investigation.

HISTORY AND LOCATION OF STUDY AREAS AND HERDS

Two study areas were established for investigation purposes, one at Mount Hamell and one on Pinto Creek.

Mount Hamell (Figs. 1 and 2) is situated at 53° 58' north latitude and 119° 13' west longitude, on the west side of the Smoky River, approximately 40 miles north of Jasper National Park.

The top of the mountain is 6,980 feet above sea level, a height of approximately 4,000 feet above the valley floor. It is isolated from the main mountain range to the south and west by approximately 4 miles of dense white spruce (Picea glauca) forest and is separated from the nearest mountain on the north and northeast by Sheep Creek and approximately 6 miles of similar cover. The nearest substantial goat population is 3 air miles to the east and southeast, but is sep - arated from the Mount Hamell population by the Smoky River which is a natural barrier to frequent movement between the two populations.

The topography from the southwest to southeast exposures varies from grassy slopes, ridges and alpine meadows interspersed with groves of aspen (Populus tremuloides), limber pine (Pinus flexilis), and alpine fir (Abies lasiocarpa) on the moister sites of less relief below 6,500 feet, to shale slopes and precipitous anticlyne cliffs and canyons. The southwestern and northeastern exposures grade downward from a grassy - alpine cover through an alpine fir - aspen community to a dense evergreen forest of white spruce. The northeast to north - west exposures support a closed evergreen forest of white spruce and alpine fir below 6,000 feet elevation. Above the white spruce, thickets

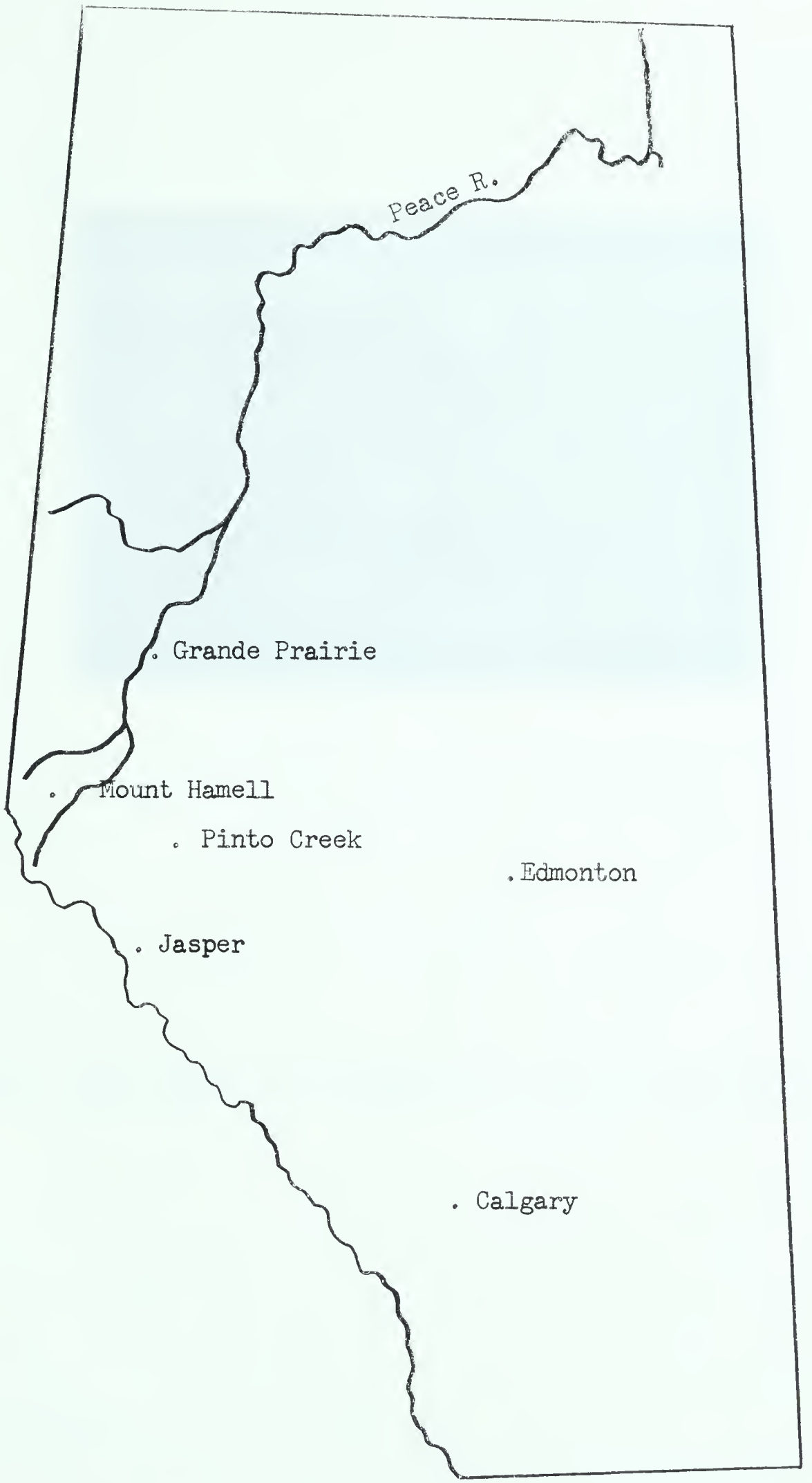

Fig. 1. Location of study areas.

Fig. 2. Mount Hamell and the Smoky River from the southeast.

of alpine fir occur on the moist more gentle slopes for another 500 feet. The upper 500 feet on all exposures supports a typical alpine grass - forb community (Moss, 1955). The southeast exposure, with the greatest number of cliffs and least amount of evergreen vegetation, was the area most frequently used by goats throughout the year.

One year prior to the initiation of my study in 1961, the United States Steel Company began to explore coal deposits on Mount Hamell and established a base camp at the foot of the mountain. During the course of their operations two roads were constructed to the top of the moun - tain as well as several in the surrounding country.

This industrial activity appeared to cause no immediate change in the mountain goat population as U. S. Steel personnel and local Indian residents claimed no noticeable difference in goat numbers after exploration began. Indirect effects of exploration in making the mountain accessible to the public are discussed later.

The total goat population inhabiting the Mount Hamell study area varied considerably throughout the course of the study. In midsummer of 1961 it was estimated at 80 animals, with a minimum of 18 kids present. By the end of 1961 a minimum of 28 animals had been removed either by hunters or had been taken into captivity. Following the kidding period of 1962 a total of 45 animals remained, eight of which were kids. Hunter harvest during that fall was relatively small with approximately 40 animals remaining in the spring of 1963. Following the 1963 kidding period 55 or more goats were present.

The Pinto Creek area (Figs. 1 and 3) is intersected by 53° 45' north latitude and 117° 50' west longitude, with almost the entire area

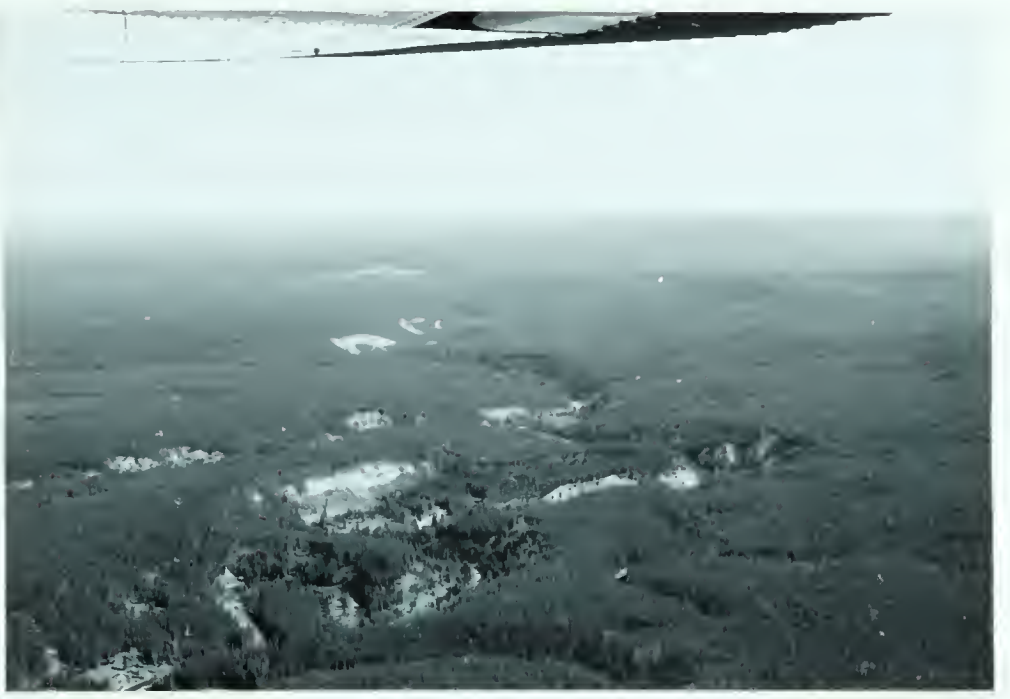

Fig. 3. Pinto Creek, showing extent of cliffs and surrounding forest cover.

being situated within township 55, range 26, west of the 5th meridian.

The area is located approximately 35 miles northeast of the main mountain range in the Boreal - Cordilleran transition zone (Moss, 1955) and consists predominantly of a white spruce and lodgepole pine (Pinus contorta) community. Moderately rolling terrain exists throughout the area with total relief being not more than 300 feet. The area utilized by goats consists of a narrow belt about 200 yards wide on each side of the creek, (Fig. 3) between the water's edge and the top of the sand - stone and shale bluffs. This narrow belt, which consists of a small tree - shrub and herb stratum typical of the Boreal - Cordilleran transition zone (Moss, 1955), interspersed with grassy openings, extends for a distance of approximately 8 miles.

Goats are known to have existed in this area for at least 20 years (Gordon Watt and William McGee, Entrance, Alberta, personal communi - cation) and have maintained a relatively constant herd size of fifteen to twenty head. In the summer of 1962, 17 goats were present consist - ing of 2 kids, 3 yearlings, 4 adult males, 1 sub - adult male, 5 adult females and 2 sub - adult females.

J. Shand - Harvey, a trapper in the area, claims that in the winter of 1931 he observed signs where wolves, after several attacks, had chased four to eight goats off the main range at the head of Collie Creek, through heavy timber and to a location very close to the Pinto Creek study area. It is felt by Mr. Shand - Harvey that the present goat herd was established on Pinto Creek in this manner. Regardless of its origin, this population remained unhunted and relatively unknown to the public until 1961 when industrial activities made the area more

accessible.

MATERIALS AND METHODS

Transportation throughout the study was by means of fixed wing aircraft, helicopter, "Burro" (mountain motorcycle), horseback and foot. Fixed wing aircraft, Cessna 180 and 185, were employed to get to and from the Mount Hamell airstrip during early spring when other modes of travel were impractical because of heavy snow cover. A Cessna was also used on winter and spring aerial surveys to determine winter herd sizes, factors affecting the location of goat winter range and to delineate goat winter ranges. An Alberta Forest Service helicopter (J 2 Bell) was used to a limited extent as transportation to and from Mount Hamell and Pinto Creek. It was also used for some of the census surveys of the country immediately surrounding the study areas. Seismograph cut lines and roads permitted the use of a "Burro", the vehicle used most extensively in gaining access to both areas during both summer and fall. Horses were the first means of transportation into the Pinto Creek area. Discovery of trails allowed the later use of the "Burro" which saved much time and effort. To prevent disturbance of the animals and because of the ruggedness of the terrain, the only practical mode of travel while on the study areas proper was by foot.

Body weights were obtained by use of a beam scale which weighed to a maximum of 300 pounds, a spring operated dial scale which weighed to a maximum of 200 pounds and a spring scale which weighed to a maximum of 50 pounds. Whenever possible the animals were weighed intact with the beam scale mounted on a pole or a 7.5 foot aluminum tripod. In some cases the animals were weighed in parts with the smallest of the three types of scales. All body weights were recorded in pounds.

Body measurements were taken with a steel pocket tape 8 feet in length. Standard measurements of total length and tail length were used. Height at the shoulder and ear length were also recorded. The length of the hind foot was taken as the maximum distance between the anterior, distal most part of the hoof and the proximal end of the tarsal bones of an unskinned animal.

Lower jaws were collected and longitudinal sections of the central incisors, .006 inches in thickness, were made by removing the crown, embedding the root in dental stone and cutting with a dental saw. The sections were then inspected microscopically for the presence of annual cementum rings.

General observations of daily and seasonal movements, activities, reproduction, behaviour, etc., were made with the aid of 7 X 35 field glasses and a 25 power Bushnell spotting telescope.

Two methods of range analysis were used throughout the study. A browse circular - plot method was used only to compare percentage composition of shrubs on two ranges and was carried out as follows. A series of circular plots, 5.88 feet in radius (1/400 of an acre) spaced fifty paces apart and approximately in a straight line, were set up across the range to be sampled. Species of shrubs present, ocular estimates of average utilization of each species and the number and type of all winter fecal pellet groups were recorded for each plot.

A line intersect - belt transect method was used to determine floral composition, preference ratings and the percentage of the diet contributed by each species. This method comprised two major phases. Phase one, in essence the line intersect method, involved the laying of

a 100 foot steel tape flat along the ground and the recording of species and percentage utilization of vegetation occurring at each foot mark. The second phase involved superimposing on phase one a rectangular plot 6.6 feet wide and 100 feet long (1/66 of an acre) with the tape forming the midline of the plot. Phase two sampled shrubs and fecal pellet groups only. Shrub information consisted of the number of each species present, the average height class and the average ocular estimate of percentage utilization by volume of each species. The percentage utilization classes were:

Class	Percentage Utilization
none	0
light	1 - 25
moderate	30 - 50
heavy	55 - 75
very heavy	80 - 100

The height classes used were:

Class	Height in feet
1	0 - 1
2	1 - 2
3	2 - 3
4	3 - 4
5	4 - 5
6	5 or more

The analysis of the raw data secured by the line intersect - belt transect method was carried out by calculation of the following para - meters.

1. Percentage composition is the percentage that any shrub species comprised of the total number of all shrubs present.
2. Volume - class is a figure assigned to each species in accordance with its relative available forage production. Each species varies in height and shape, thus each produces a dissimilar volume of

available forage. For this reason volume - classes (V. C.) are designed to represent the ocular estimations of relative volumes of usable forage produced by each species. To illustrate, if rose produces x amount of usable forage and poplar produces one and one - half times as much, then rose receives a value of 1.0 and poplar a value of 1.5.

3. Percentage of total forage production is equal to

$$\frac{\text{percentage composition x V. C.}}{\frac{\Sigma \text{ V. C.}}{N}},$$

and the quotient converted to a percentage.

N is the number of species present. $\frac{\Sigma \text{ V. C.}}{N}$ thus represents the mean volume class of all species.

4. Percentage of the diet equals percentage composition x volume class x average utilization, and the product converted to a percent - age

5. Preference rating is the quotient of

$$\frac{\text{Percentage of the diet}}{\text{Percentage of total forage production}}$$

Samples of stomach contents were taken from several areas of the rumen and stored in A. F. A. (alcohol, formaldehyde and acetic acid; Cowan, 1951) until examined in the laboratory. These samples were then washed through a 6 mm. mesh screen and the remaining material identified. Identified portions were measured on a percentage by volume basis (water displacement) by use of 1,000 ml and 100 ml graduated cylinders.

All common names of plant species follow Moss (1959).

Collected and hunter killed animals were examined in the field for external parasites and obvious diseases. Samples of various internal organs, primarily of the digestive and respiratory tracts, were preserved

in A. F. A. until they could be examined further in the laboratory under magnification.

Kill statistics were obtained from personal interviews with local residents and from the records of the big game checking station operated at Entrance by the Fish and Wildlife Division, Alberta Department of Lands and Forests.

PHYSICAL CHARACTERISTICS

Body Weights and Measurements

Body weights and measurements (Table 1) were taken from all animals captured on both study areas. To my knowledge these are the only weights of mountain goats recorded in Alberta. All mountain goats found north of the Bow River in Alberta are considered to be O. a. americanus (Cowan and Guiguet, 1956) and it is presumed therefore that all measurements in Table 1 are from this subspecies.

All comparable weights and measurements for these Alberta goats are considerably larger than those recorded by Brandborg (1955) for goats found in the northwestern United States. Weights obtained by Lentfer (1955) for goats from virgin goat range in the Crazy Mountains, Montana, were intermediate between those from the northwestern United States and those from Alberta. Lentfer attributes the greater weights of the goats from the Crazy Mountains to the fact that they were a newly introduced herd with an abundant food supply. Goats occurring throughout the United States are classified as O. a. missoulae and are the smallest of the three known subspecies (Brandborg, 1955) while americanus is the subspecies intermediate in size (Cowan and Guiguet, 1956).

Sequence of Moult

During the course of the study it was noted that while the moult pattern was the same for all individuals, the time of moult varied with sex and age.

Initiation of moult was first apparent on adult males the last week of April. In general adult males and non - pregnant females began to

Table 1. Weights (pounds) and measurements (inches) of west Alberta mountain goats.

Specimen No.	Approximate Age	Sex	Weight	Total Length	Height at Shoulders	Hind Foot	Tail Length	Ear Length	Date of Death
				KIDS					
12	** 0	M	6.25	19 3/8	14 1/8	6 1/8	1 5/8	2 3/8	18/5/63
	5-7 days	F	8.12	24	14 1/4	6 3/4	2 1/2	2 1/2	
	7-10 days	F	9.2	25 1/2	15	--	--	--	
	7-10 days	F	9.2	26	15	--	--	--	
14	2 weeks	F	16.5	28	17 1/2	8	2 1/2	2 3/4	8/6/63
	14-20 days	M	13.4	26 1/2	15 1/2	7 3/4	2 1/4	2 3/4	
9	*21 days	F	--	27	16 1/2	7 1/2	2 3/4	2 3/8	7/6/61
22	6 weeks	F	27	33 1/4	21 1/4	9	3	3 1/4	13/7/63
25	3 mos.	M	64	38	27 3/4	10 1/2	3 1/4	4	2/9/63
28	6-7 mos.	M	71	44	27	11	3 3/4	4 3/8	5/12/63
				TWO - YEAR - OLDS					
13	24 mos.	M	100	47 1/4	33	12 1/4	3 3/4	4 3/8	6/6/63
				THREE - YEAR - OLDS					
11	36 mos.	F	108.1	50 1/2	33	12 1/2	4 3/4	4 1/2	18/5/63
29	42-43 mos.	F	173	57	37	12 1/2	4 1/4	4 1/2	5/12/63

Table 1. (Continuation)

Specimen No.	Approximate Age	Sex	Weight	Total Length	Height at Shoulders	Hind Foot	Tail Length	Ear Length	Date of Death
				FOUR YEARS AND OVER					
23	49-50 mos.	M	192	62 1/4	41 1/2	13 3/4	5	5	25/7/63
3	51-52 mos.	M	--	58 1/2	33 3/4	--	--	--	2/9/61
2	51-52 mos.	M	--	60	35 3/4	--	--	--	1/9/61
10	63-64 mos.	M	246.5	61 1/2	36 1/2	14	5 3/4	--	25/8/62
1	72-73 mos.	M	--	64 1/2	37 1/2	--	--	--	1/9/61

* From Alberta Game Farm - captured at 1 - 2 days of age. Fed artificially until death.
** Premature kid present in specimen number 11. Estimated at 2 weeks from parturition.

moult first, subadults of both sexes next and females pregnant or with kids last.

It was found that there was sufficient difference in time of moult between pregnant and non - pregnant adult females to allow an estimation of the current year's kid crop by about 10 May, or a week prior to the birth of the first kid. As the kidding period progressed the differences became more apparent, so that by the end of May the total kid crop, reached in about mid - June, could be quite accurately predicted.

To my knowledge the relative time of moult has not been used as a means of predicting reproduction amongst mountain goats prior to this study. Brandborg (1955) observed the difference in time of moult between the sexes but did not utilize it in this manner. Differences in moult between sexes and between pregnant and non - pregnant females are shown in Figs. 4, 5 and 6.

Development of Annual Horn Rings

Known - age animals (Table 2) checked at the Alberta Game Farm, east of Edmonton, showed no ring at 12 months but one annual horn ring at 24 months even though they had been fed artificially during their first two winters. Comparison of weights of the two 24-month-old males (Table 3) and specimen number 13 (Table 1) indicates that artificial winter feeding caused increased growth or at least kept the animals in better condition. Horn lengths of the two known - aged males, 9.25 and 9.0 inches (Table 2) compared with the horn length of specimen number 13 at 7.5 inches, suggests that horn growth was greater under artificial con - ditions. It is assumed that horn development occurred throughout the winter although possibly at a reduced rate. The one annulus present on

Fig. 4. Male mountain goat showing complete moult except on rump area, 13 July, 1963.

Fig. 5. Female goat with kid showing retarded moult on the female, 13 July, 1963.

Fig. 6. Pregnant nanny, left, and non - pregnant female, right, showing difference in extent of moult, 8 June, 1963.

Table 2. Incisor replacement and horn measurements (inches) of known - aged goats, Alberta Game Farm.

Age	Sex	Incisors 1	2	3	Canine 1	Horn Length	Circumference of base	Horn Rings Present
12 mos.	M	M	M	M	M	6	3 3/4	0
24 mos.	M	A	M	M	M	9 1/4	5 1/8	1
24 mos.	M	A	(A)	M	M	9	5	1
24 mos.	F	A	M	M	M	9	4 1/4	1
24 mos.	F	A	A	M	M	7 7/8	4 3/8	1

A - adult tooth

M - deciduous tooth

brackets - tooth erupting or being replaced

Table 3. Weights (pounds) and measurements (inches) of goats at Alberta Game Farm.

Age*	Sex	Weight	Total Length	Height at Shoulder	Hind Foot	Tail Length	Ear Length
12 mos.	M	61	46	26 1/4	11	3 3/8	3 3/8
24 mos.	M	132	56	32	13	4 1/8	4 1/8
24 mos.	M	124	59 1/4	35 3/4	13 3/4	4 1/4	4 1/8
24 mos.	F	105	56	31 1/2	12 3/4	5	4 1/2
24 mos.	F	96	55 1/2	33	12	3 3/4	4 1/4

* Ages are accurate to within 3 weeks.

Note: Hind foot and height at shoulder measurements may not correspond to similar measurements of goats in the wild due to abnormal hoof development as a result of lack of wear.

the 24-month-old artificially fed goats was equally as distinct as annuli found on goats in the wild. For the above reasons it is felt that annulus formation is not a result of food scarcity but rather of some other factor, possibly the activities of the rut, which did occur although unsuccessfully in the pen - raised animals about 6 months prior to the time that measurements were taken. Cowan (1940) suggested that development of annual horn rings in bighorn sheep was a result of increased sexual activity during the breeding season.

Methods of Age Determination

Most animals over 1 year of age handled during the course of this investigation were assigned an age by means of the horn ring method. Age in years equals the number of annual rings plus 1 year (Brandborg, 1955). No inconsistencies were found with this method but difficulties with some females and for animals over 7 to 8 years of age of both sexes were experienced. It was noted that nannies did not have as distinct annual rings as did billies, often making it difficult to determine whether a sulcus was an annual ring or just a periodic convolution in the horn sheath caused by movement of the sheath along the horn core during normal horn growth. In animals over 7 to 8 years of age the linear horn growth became so minute and the annual rings so close together it became very difficult to count the rings accurately. Brandborg (1955) also mentions the difficulties involved in determining the number of rings on older animals.

Horn Length

One hundred and eighteen horn measurements were taken from animals

on and around the two study areas (Table 4). It can readily be seen from this table that there is a great deal of individual variation within the same age - class as well as considerable overlap in average horn length of the different age - classes, thus making it impossible to determine the age of mountain goats by means of horn length alone. Horn length, coupled with body weights (Table 1) may give some indica - tion of age for animals 3 years of age or less but is by no means an accurate criterion for age determination of mature animals. Similar variation in horn length of different age - classes was found by Kindell (1961).

Body Weights

Weights of goats appear to increase with age until about age 3 years (Table 1). It may be possible to use body weight as an age determination characteristic but it would be necessary to differentiate between sexes and to compensate for the physical condition of the animal which varies quite markedly with the seasons. It is not likely that determining age in this manner will become a common technique since hunter killed animals are usually in relatively inaccessible areas, making the securing of weights extremely difficult.

Teeth as an Aging Criterion

Records were kept of the presence and condition of all permanent and deciduous teeth of all mountain goats handled during the investi - gation. The results are summarized in Table 5.

Captive, known - aged goats at Alberta Game Farm were inspected for the presence of permanent teeth (Table 2) and the information obtained

Table 4. Age and horn length of Alberta mountain goats shot between Sept. 1 and Oct. 31. Ages were assigned by means of horn rings (Brandborg, 1955).

MALE			FEMALE		
Average Length (inches)	Range	Sample Size	Average Length	Range	Sample Size
		YEARLINGS			
7	5 4/8 - 7 7/8	8	4 6/8	4 - 5 4/8	2
		TWO - YEAR - OLDS			
8 1/8	7 2/8 - 8 6/8	8	7 7/8	7 5/8 - 8 7/8	5
		THREE - YEAR - OLDS			
7 6/8	7 - 8 4/8	5	7 3/8	6 3/8 - 9	4
		FOUR - YEAR - OLDS			
8 3/8	8 - 10 1/8	19	7 4/8	6 4/8 8 3/8	6
		FIVE - YEAR - OLDS			
8 7/8	8 - 9 3/8	15	8 4/8	7 6/8 - 9	5
		SIX - YEAR - OLDS AND OVER			
9 1/8	7 6/8 - 10 2/8	28	8 3/8	7 4/8 - 9 4/8	13

was found to closely parallel information collected from the wild. The captive animals showed a slightly earlier eruption of I_2 but this may well be a result of artificial feeding.

During the time of inspection of goat teeth it was noted that, without exception, the upper premolars and molars were later in eruption than were the corresponding teeth in the lower jaw.

As shown in Tables 2 and 5, the age of goats can be determined quite accurately by tooth eruption and replacement to the age of 4 years. Data are not yet available to enable the accurate determination of ages of goats beyond 4 years by the use of external dental features.

Data collected during my investigation on the tooth replacement and eruption of goats correspond almost exactly with similar data collected by Brandborg (1955) for the subspecies missoulae. There - fore it is possible to use the same tooth replacement method of age determination throughout the ranges of both subspecies, americanus and missoulae.

In order to extend the use of dental features beyond 4 years of age, sections of I_1 of eight goats were examined. Longitudinal sections were cut without decalcification with a dental saw at a thickness of .006 inches. These were then inspected microscopically, unstained, for annual rings in the cementum layer but no rings could be distinguished.

It is felt that any technique to be useful in wildlife management must be both accurate and relatively quick. It was estimated that 2 - $2\frac{1}{2}$ hours were necessary to completely prepare and examine one tooth by this method. The method involving decalcification described by Low and Cowan (1963), would undoubtedly have taken even longer. In my estimation

Table 5. Correlation of age and teeth present in lower jaw.

Specimen No.	Approximate Age	Incisors			Canine	Premolars			Molars		
		1	2	3	1	2	3	4	1	2	3
14	10 days	m	(m)	(m)	((m))	(m)	m	m			
9	21 days	m	m	m	m	m	m	m	((A))		
22	6 weeks	m	m	m	m	m	m	m	((A))		
25	3 mos.	m	m	m	m	m	m	m	(A)		
28	6 - 7 mos.	m	m	m	m	m	m	m	A	((A))	
13	24 mos.	A	(A)	m	m	m	m/(A)	m/(A)	A	A	(A)
11	36 mos.	A	(A)	(A)	A*	A	A	A	A	A	A
29	42 - 43 mos.	A	A	A	m/(A)	A	A	A	A	A	A
23	49 - 50 mos.	A	A	A	A	A	A	A	A	A	A
3	51 - 52 mos.	A	A	A	A	A	A	A	A	A	A
2	51 - 52 mos.	A	A	A	A	A	A	A	A	A	A
10	63 - 64 mos.	A	A	A	A	A	A	A	A	A	A
1	72 - 73 mos.	A	A	A	A	A	A	A	A	A	A

Determination of age follows horn ring method described by Brandborg (1955), and correlated with known kidding period, for animals 24 months or over.

A - adult tooth m - milk tooth * deciduous tooth dropped, permanent tooth in early development beneath bone

( ) - erupting through gum

(( )) - erupting through bone but not gum

this method of age determination is not practical as a management technique where large samples must by analyzed and for this reason was not investigated further.

BEHAVIOUR

Senses

Mountain goats appear to have a very keen sense of sight, which allows little movement to go unnoticed. It appears however that stationary objects cannot be identified by goats. On many occasions goats have approached to within 50 yards of me, and on two occasions to within 25 feet of me while I was sitting motionless on an open slope. On all occasions I was apparently recognized as something new or dif - ferent to them which attracted their attention and caused them to investigate me further at close range. In all instances however, movement on my part after having been detected caused the goats to take flight.

Olfaction appears to be poorly developed or relied upon very little by goats. On several occasions goats were approached from upwind to within 50 yards and on one occasion to within 15 feet without the goats detecting my presence until I was in sight of the animals. On still another occasion a black bear (Ursus americanus) was observed to pass within 100 yards upwind of a bedded goat herd. The goats showed no evidence of having detected its presence.

The above findings are in general agreement with those of Brandborg (1955).

Voice

Vocal sounds of mountain goats are rarely heard, and then only under ideal conditions and at close range. The most common sound heard was the bleat of the kid for its nanny, or the nanny for its kid. I did not hear the high squeak supposed to accompany udder - butting

(Brandborg, 1955) or the deep, hoarse grunt described by Seton (1927).

On one occasion two adult males were heard uttering a high pitched moan as they paced back and forth threatening each other in a dispute over which would occupy a shady bed site. This sound was heard under calm conditions at a distance of approximately 600 yards. To my know - ledge this is the first record of this vocalization.

Daily Movements and Activities

During the summer months goats generally began feeding about 1 hour before sunrise and continued feeding until 0900 to 1000 hours. It was common then to see them bedded on well established bedding grounds (Fig. 7) which were exposed to the sun and wind. With the approach of mid - day and rising temperatures, the goats left these "sunning" grounds and sought a cooler place in the shade. Goats were seen feeding at any time of the day but most of them remained bedded until it began to cool in the late afternoon. During the period from mid - June to mid - September the goats were usually most active from 1600 hours until dark, with all animals moving about feeding.

Small bands of goats were observed to remain in the same area for days, or even weeks if not disturbed, and were seen to use the same bedding areas day after day. There appeared to be some tendency for each individual to use the same bed each day. This was most evident among groups of billies. Six billies which remained in loose associ - ation with one another during late August were observed to use the same shady beds for several consecutive days. On one occasion a small male bedded in another male's bedding site. The larger male, which had been using that bed for days, immediately chased the intruder away and lay

Fig. 7. Exposed bedding ground showing obvious, much used bed sites.

down himself. There was some evidence of ownership of bedding sites among mixed bands of males, females and young but this was not nearly so evident. Because of the continued use of the same bedding areas, and the fact that the goats pawed these beds each day, rather large depressions are made in the shale, thus making the grounds relatively easy to locate. It was also noted that the goats used the same bedding grounds from one year to the next.

Changes in weather altered the pattern of daily activities. During warm or hot weather the periods of feeding and bedding were marked while on cool or cloudy days the separation of activities was much less distinct. Cool weather found the animals feeding spasmodi - cally throughout the day or remaining on exposed bedding sites all afternoon. Rain and snow flurries often caused goats to seek sheltered areas, with active periods of feeding or movement occurring during breaks in the storm.

Goats as a rule did not travel great distances at night but were on some occasions observed to have moved as far as 2 miles under cover of darkness.

For the most part daily activities remained unchanged throughout the year. As cool weather approached in late fall however the peaks of activity were less marked, as was the case in early spring.

Brandborg (1955) states that the two most common activities of goats were feeding and bedding but that there was an increased activity among males throughout the day in November and December, as this is the time of rut and males are constantly in search of receptive females.

Seasonal Grouping

Fig. 8 shows graphically the average monthly herd sizes as determined by my investigation and by Brandborg (1955). Table 6 portrays the Alberta average monthly herd sizes numerically as well as extreme monthly herd sizes and number of observations made during each period.

During the period from mid - September to early April very few observations were obtained since I was attending university classes at that time. Brandborg (1955) has many observations for this period and since his data closely parallel that of Alberta goats for the remainder of the year, it is assumed that Alberta herds follow the same pattern as missoulae for those periods during which Alberta records are not available.

A suggested explanation of the curve in Fig. 8 is as follows. The gradual increase in herd size during the winter is very likely a result of increasing winter snows which concentrate the goats on their winter range. Behaviour leading up to and persisting throughout the rut, which occurs from mid - November to mid - December, may also cause the animals to form larger herds. Only three observations of goat herds were made during the breeding season and consisted of 41, 24 and 3 animals respectively, making a monthly average herd of 26 (Table 6). Since the sample size is small and the range in herd size is great, it is not considered to be a true representation of monthly average herd size and is not included in Fig. 8. Brandborg (1955), Fig. 8, has many more observations for this period and it is felt the Alberta curve should more closely resemble his observations. The greatest snow accumulation

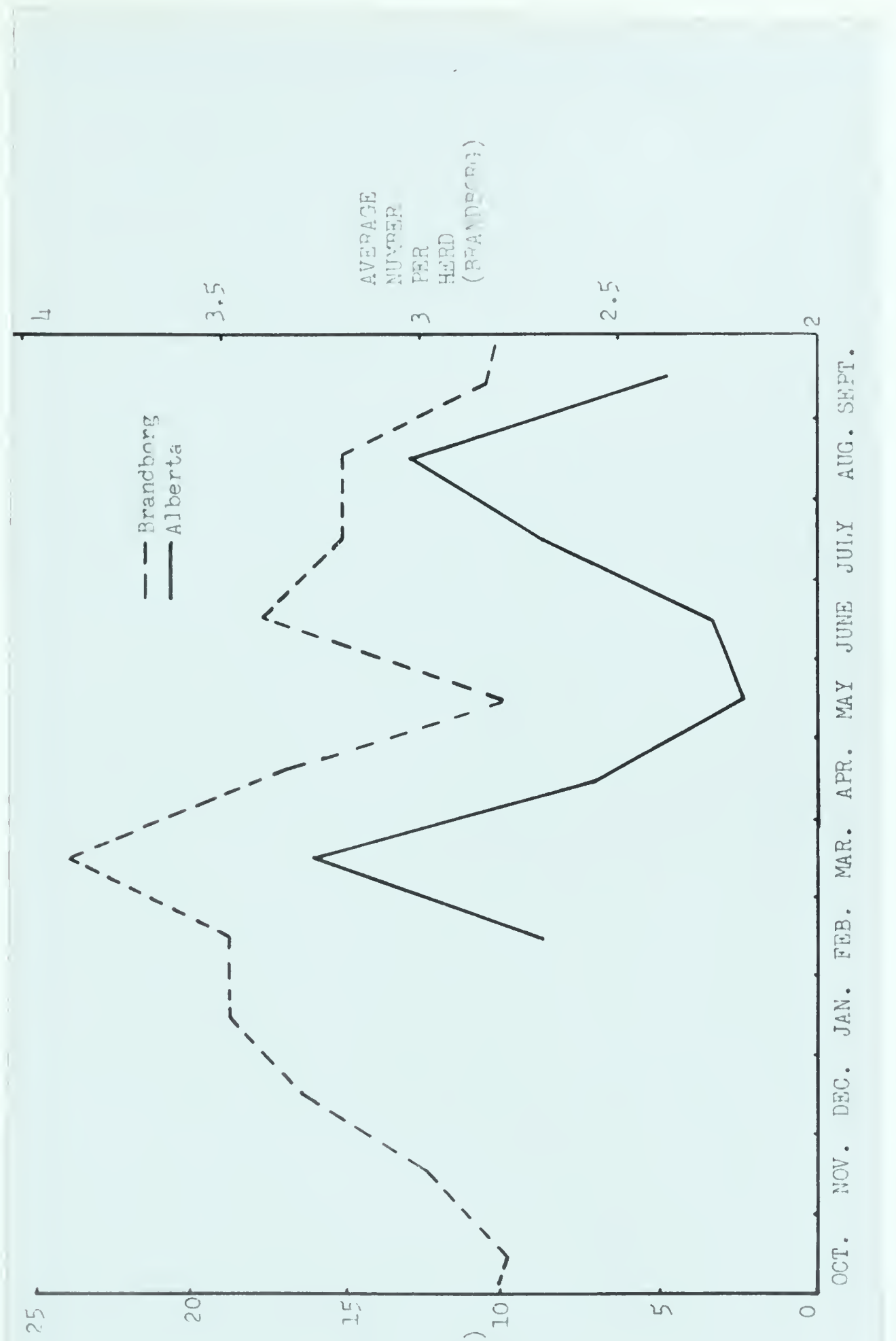

Fig. 8. Average monthly size of goat herds in Alberta (Mt. Hamell) and in Idaho (Brandborg).

Table 6. Average monthly herd size of goats in Mt. Hamell area.

Month	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Average Herd Size	26		8.8	16	7	2.5	3.5	8.8	12.9	5
Extremes	3-41		1-45	12-18	1-33	1-12	1-17	1-34	1-37	1-23
No. of observations	3		11	8	29	126	80	34	20	27

in the mountains at the latitude of Mount Hamell generally occurs in March and it is during that month that the goat herds were the largest (Fig. 8 and Table 6). Mid - April usually marks the onset of spring. As the snow melts more range becomes available to the animals and allows them to scatter in smaller groups. During late April and early May mature males leave the winter herds to become solitary or form small groups of their own, thus reducing the average herd size. Pregnant females, which seek solitude at parturition, begin to leave the larger herds in early May. By mid - May, when first kidding occurs, the smallest average herd sizes were observed.

A few days after parturition the females with their young begin to group together so that by the end of the kidding period in mid - June the average herd size has again risen slightly. As the kids become older and the nannies become more tolerant of yearlings and 2-year-olds being nearby, the average herd size becomes still larger.

By mid - July and August most of the snow is gone from the moun - tains and vegetation is green to the highest elevation. The goats then wander to the maximum extent of their range and in dispersing reduce the average herd size.

From mid - April to the end of July it is not common to see mature males in mixed groups of nannies, kids and subadults. The males are then generally at higher elevations and either solitary or in groups of all mature males. As summer progresses however, and nearly all goat herds are at high elevations, it becomes increasingly common to see mature billies with large groups of other goats.

The first effects of the approaching rut are apparent by late

August or early September as evidenced by increased antagonism between mature males. Groups of males which exist through late spring and summer slowly begin to disband with members becoming primarily solitary or forming what might be considered "loose" groups. It was not uncommon to see up to six mature males in the same area for several days, but all their daily activities kept them spaced from 50 to 300 yards apart. They all appeared to have some loose association with one another, but seldom was one seen less than 50 feet from another. Closer approach generally resulted in aggressive behaviour, with one animal rushing at another causing the attacked to move away.

With the coming of the first winter snows in October and rut activities increasing, the goats begin to move back to their winter ranges, causing the average herd size to increase once more.

Geist (1964), working in British Columbia, found there was a tendency for animals to scatter and form small groups and pairs during the breeding season. He also noted however that snow and weather conditions affected the distribution of goats at this time, with heavy snow preventing the wide distribution of animals and resulting in larger herds. Brandborg (1955) noted a tendency for goats to form large groups during the rut except in areas where goat density was low.

Seasonal Movements and Distribution

Except for goats which winter at low elevations and thus are already close to the valley floor, there is a definite downward movement with the onset of spring about mid - April. This movement is probably a response to new vegetative growth which begins to appear on the lower mountain slopes at that time. Following this initial downward movement, which is

quite temporary, there is a gradual upward movement which continues throughout the summer. The upward movement of goats on Mount Hamell was gradual but unmistakable, with the majority of goats being observed at successively higher elevations with each passing week. There appeared to be a definite correlation between the elevations at which the animals were found and the elevations at which new vegetative growth had become evident.

Brandborg (1955) and Shaw (1958) noted the descent of goats in April and early May. Brandborg stated, "It appears that they descend the slopes for the new growth of forbs and grasses available on the warmer sites." Lentfer (1955) stated that the late spring ascent of goats appeared to be associated with receding snowbanks and intimated that they use these primarily as a source of water. On Mount Hamell virtually all snowbanks were gone by mid - July and goats did not appear to be associated with the few that were left. I feel that the spring and summer ascent was governed by the condition of new vegetative growth and not by receding snowbanks or water supply.

Mature males, some 2-year-olds and a small percentage of yearlings precede the pregnant females in their spring and summer ascent. Females, pregnant or with new born kids, remain at lower elevations, often quite near their winter range until a week or two after parturition. Lentfer (1955) also found that females remain at low elevations during that period.

It is common to see yearlings in association with nannies and new kids, often in groups of three, during the early parturition period. Presumably these groups consisted of the nanny and kid of the year, plus her kid of the previous year. There was a marked intolerance on

the part of the nanny towards the yearling at this time. If the year - ling ventured too close to the new kid it was immediately chased away. This intolerance of the yearling was also noted by Lentfer (1955) and Brandborg (1955).

The majority of kidding occurs at about 4,000 feet elevation with a small percentage occurring approximately 1,000 feet higher. Females with kids were first observed at the top of the mountain, near 7,000 feet, in mid - July, or about 2 months after the first kids were born.

Goats on Mount Hamell were found at various elevations throughout the summer, but primarily above 5,000 feet.

There was a general downward movement to winter range in the late fall. A descent to winter ranges was also noted by Lentfer (1955) and Brandborg (1955).

Horizontal distance travelled by goats during their seasonal migrations is relatively small. The Mount Hamell goat herd for the most part at least, remained the entire year on the mountain. This was evidenced by the fact that about the same number of goats was found on the mountain throughout the year and that some recognizable individ - uals were always present. The maximum horizontal distance which could be travelled on Mount Hamell is approximately 3 miles. Movements of goat populations on the main range to the southwest indicated that their maximum annual migrations may have involved as much as 5 to 7 miles. Brandborg (1955) and Shaw (1958) found the horizontal migration of goats to be relatively small and in the vicinity of 15 miles.

FOOD HABITS

Winter

It was felt that the supply of food used by mountain goats during the late spring, summer and early fall is unlimited while the supply of food during the winter, as a result of restricted range size, is critical and possibly a limiting factor. For this reason considerable effort was expended in the investigation of winter food habits. This concurs with the feelings of Cowan (1950), "In common with the moun - tainous areas throughout northwestern North America there is a critical scarcity of winter range. Not more than 10 per cent of the parks area carries the game herds through the 5 months' winter season." Also as stated by Cowan (1952), "Winter ranges are the key to survival."

General reconnaissance of both areas prior to carrying out range transects showed considerable shrub utilization but little evidence of utilization of grasses or grass - like plants. Brandborg (1955), Longhurst (1957), and Klein (1961), in studies ranging from the southernmost populations in the United States to Alaska, found that browse was the primary winter food of goats. Assuming therefore that shrubs made up the major part of the winter diet of goats in Alberta, it was decided that range transects would be run primarily to sample shrubs rather than other vegetative types. The above assumption receives further support from winter stomach content analysis (Table 7). These limited samples reveal an obvious difference between winter and summer food habits. December stomach contents comprised an average of 92.7 per cent shrubs while forbs and grasses made up only 7.5 per cent. Summer samples, on the other hand, contained predominantly grasses and

Table 7. Stomach sample contents.

	# 28 Dec. 5	# 29 Dec. 5	# 13 June 6	# 14 June 8	# 23 July 25	# 10 Aug. 25
Vegetative types	% Composition	% Composition	% Composition	% Composition	% Composition	% Composition
Alpine fir	82.5	64.8		6.6	trace	
Common bearberry (*Arctostaphylos uva - ursi*)	1.5	2.4		10.0		4.6
Silver - berry (*Eleagnus commutata*)	8.2	26.0			5.0	
Willow (*Salix* sp.)						10.0
Alder (*Alnus crispa*)						trace
Unidentified shrubs				5.0	7.5	
Shrubs - Total	92.2	93.2	4.6	21.6	12.5	14.6
Grasses	8.2	6.8	91.8	78.0	75.8	80.0
Forbs	trace	trace	3.6	trace	11.6	5.4
Total sample volume	421 ml	380 ml	100 ml	50 ml	250 ml	430 ml
Total volume of identifiable portion	151 ml	250 ml	55 ml	30 ml	123 ml	220 ml

% Composition was determined from total identifiable portion
Sample Nos. 28, 29, 13 and 14 from Mt. Hamell; sample nos. 10 and 23 from Pinto Creek

forbs. The percentage composition of alpine fir in stomach contents of numbers 28 and 29 (Table 7) is probably not a true representation of its importance in the winter diet of goats as these animals had just fed through a fir stand prior to being collected. Alpine fir is probably of lesser importance in the diet than this analysis indicates.

Range transects using the line intersect - belt transect method were run on winter range of both study areas during the early spring in order to assess utilization and floral composition during the previous winter. The results of these transects are shown in Figs. 9 and 10 as well as Tables 8 and 9.

As is evidenced in Tables 8 and 9, the relative position of the preference rating of a species does not necessarily correspond with the percentage of total forage production rating. Similarly, neither necessarily corresponds with this same species' percentage of diet rating. Stoddart and Smith (1955) state that the diet of an animal is a product of forage preference and availability and that preference or utilization in themselves are poor indices of the importance of a species in the diet. The percentage of the diet of an animal which is made up of any one species of plant is however a direct index of the importance of the plant on the range of the animal.

It must be remembered when determining percentage of diet and preference ratings that these figures are not exact but only relative values. Because volume classes assigned to each species were ocular estimates of available forage production, the final values arrived at can be no more than estimates. With these limitations in mind, food habits and preference ratings of goat browse can be broken down on a

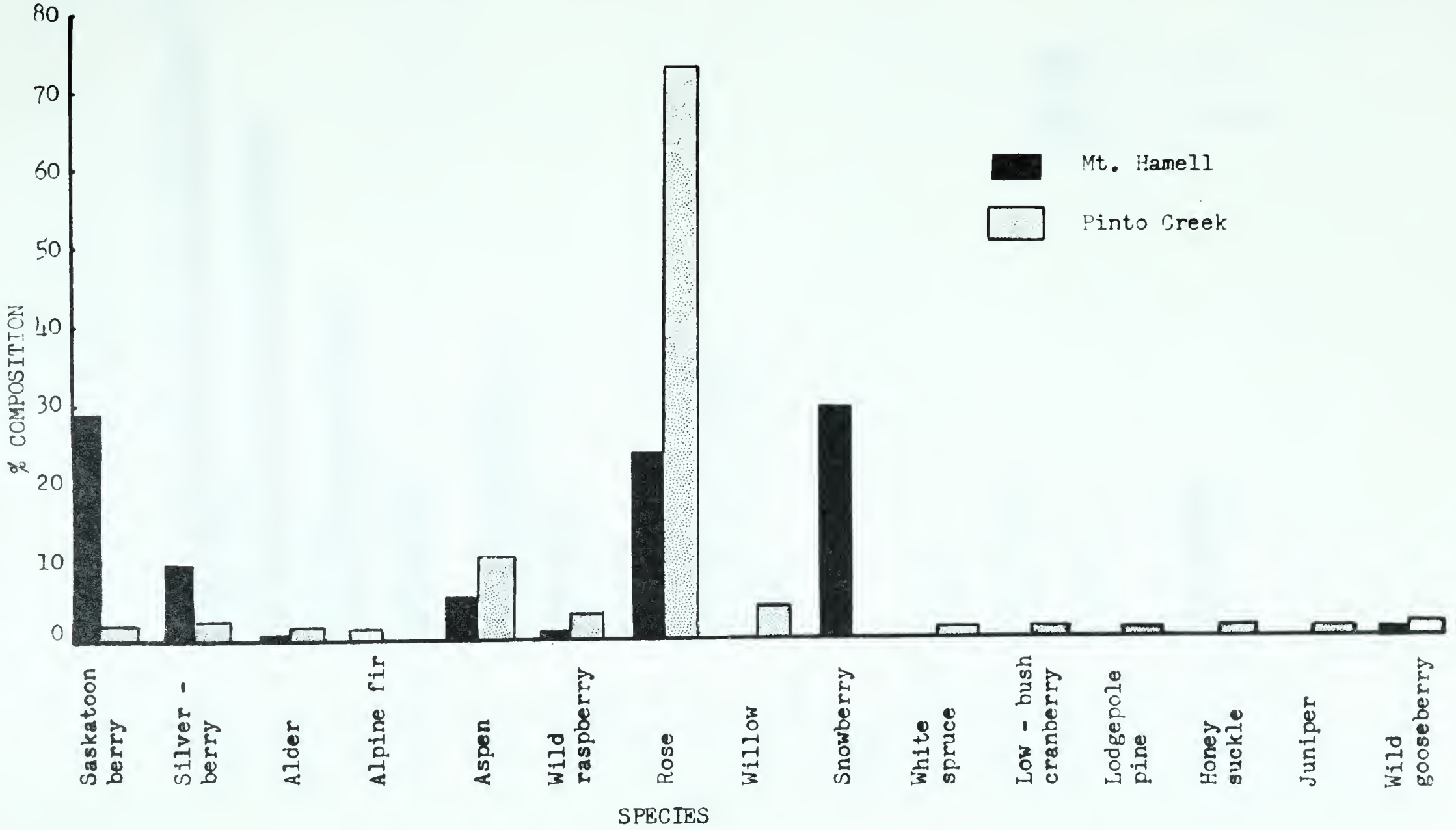

Fig. 9. Winter range composition.

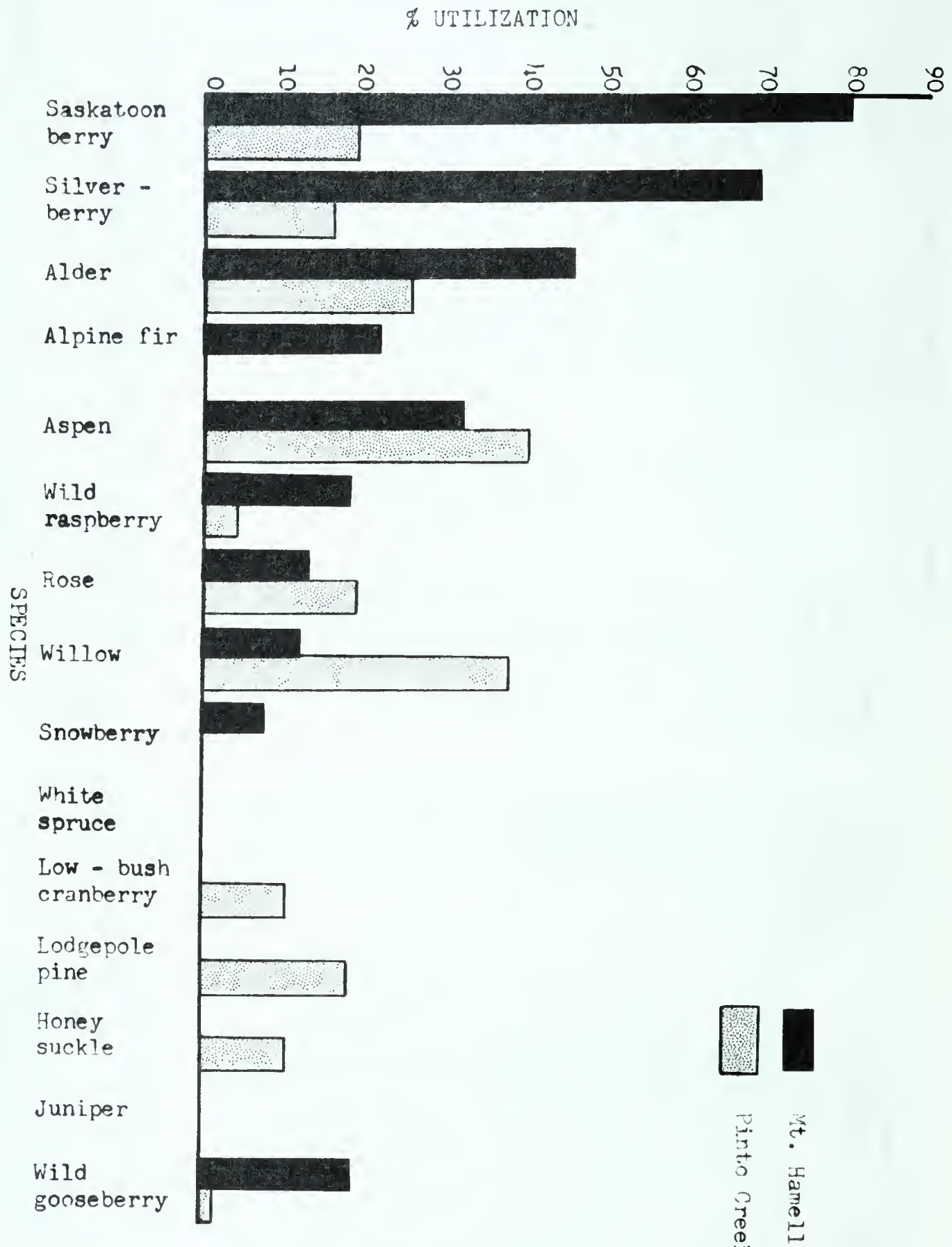

Fig. 10. Winter range utilization.

Table 8. Range transect analysis, Mt. Hamell.

Species	Percentage floral composition	V. C.	Percentage total forage production	Average percentage utilization	Percentage of diet	Preference rating
Saskatoon berry	28.4 (a)	3(b)	31.9 (c)	81.7 (d)	52.4 (e)	1.6 (f)
Silver - berry *	10.0	6	22.5	70.1	31.6	1.4
Alder	0.8	5	1.5	46.3	1.7	1.1
Alpine fir	0.4	8	1.2	22.3	1.3	1.1
Aspen	5.2	5	9.7	33.0	6.5	0.6
Wild raspberry	0.9	2.5	0.9	18.5	0.3	0.4
Rose	24.0	1	9.0	13.2	2.3	0.3
Willow	0.1	4	0.2	12.5	trace	0.2
Snowberry	30.4	2	22.8	8.0	3.6	0.2

$\bar{x}$ V. C. $= \frac{\Sigma \text{ V. C.}}{N} = 4.0$

N - number of species in total floral composition

Percentage total forage production - $\frac{a \times b}{\frac{\Sigma b}{N}} = y$; $\frac{y}{\Sigma y} \times 100 = c$

Percentage of diet - $a \times b \times d = q$; $\frac{q}{\Sigma q} \times 100 = e$

Trace - any value less than 0.1

Preference rating - $\frac{e}{c}$

*Silver - berry includes some buffalo - berry (Shepherdia canadensis), which was very lightly utilized and of low density.

Table 9. Range transect analysis, Pinto Creek.

Species	Percentage floral composition	V. C.	Percentage total forage production	Average percentage utilization	Percentage of diet	Preference rating
Saskatoon berry	0.8 (a)	2 (b)	1.2 (c)	18.7 (d)	3.9 (e)	3.3 (f)
Lodgepole pine	0.1	4	0.2	17.5	0.5	2.5
Silver - berry	4.1	2.7	7.5	37.5	17.5	2.3
Aspen	11.9	2	16.8	40.8	31.3	1.8
Alder	0.9	8	5.0	25.4	5.7	1.1
Low - bush cranberry	3.0	2	3.9	10.2	3.9	1.0
Rose	70.1	1	50.4	18.7	30.9	0.6
Raspberry	2.8	1	1.8	3.5	0.3	0.2
Honey suckle	1.9	2	2.8	10.2	0.5	0.2
Willow	1.6	4	4.6	16.0	5.0	0.1
Wild gooseberry	2.0	2	2.8	0.6	trace	0.0
Juniper	0.3	4	0.9	0.0	0.0	0.0
White spruce	0.5	8	2.8	0.0	0.0	0.0

$$\bar{x}\ \text{V. C.} = \frac{\sum \text{V. C.}}{N} = 3.2$$

general basis.

Table 8 shows that major browse species during the winter on Mt. Hamell were, on the basis of percentage of diet, saskatoon berry (Amelanchier alnifolia) and silver - berry. Secondary browse species were rose (Rosa spp.), aspen (Populus tremuloides), snowberry (Symphoricarpos spp.), alder, and alpine fir. The minor species were willow, and wild gooseberry (Ribes spp.).

Table 9 shows that shrubs which formed the major part of the winter diet on Pinto Creek were rose, aspen and silver - berry, of secondary importance were saskatoon berry, low - bush cranberry (Vibernum edule), willow and alder, while of minor importance were raspberry (Rubus spp.), wild gooseberry, honey suckle (Lonicera spp.), and lodgepole pine.

Range transect analyses have shown saskatoon berry to be an important item in the winter diet of mountain goats. The absence of this shrub in the stomach content analysis (Table 7) is probably due to the fact that the two specimens (numbers 28 and 29) were collected off of their normal range and had been feeding for about 24 hours in an area almost devoid of saskatoon berry. Common bearberry was found in the winter stomach sample contents (Table 7) but utilization of this shrub was not detected by the range transects (Tables 8 and 9). Light utilization of this dense, mat - forming shrub is very difficult to determine and may have been overlooked on the transects, however, moderate or heavy utilization would not likely have gone unnoticed. Common bearberry may be utilized by goats during winter but it is not thought to be of major importance in the diet.

The relative importance in the diet of browse plants in Tables 8

and 9 appear to be related directly to range composition or density of the different species. This was not the case with undesirables such as buffalo - berry (Shepherdia canadensis), white spruce, wild gooseberry and juniper (Juniperus communis and J. horizontalis). In other words, where a plant is more abundant, it may constitute a greater portion of the diet, thus becoming a more important browse plant than some which are more highly preferred, but less abundant. An example of the above is evident in that on Mount Hamell, saskatoon berry was of primary importance in the diet, both because of its high preference and its high density. On the Pinto Creek area, however, it was of secondary importance because of its low density, even though its preference rating was the highest (Fig. 9 and Tables 8 and 9).

Table 10 shows that although different shrubs occurred and in different densities on both study areas, those species common to both areas usually occupied much the same relative order of preference. On both ranges the two most highly preferred plants were saskatoon berry and silver - berry. If a plant is of relatively low density but is quite highly utilized, it is apparent that this plant is preferred. On the other hand, if a plant has a high density but is only lightly utilized, it must have a low preference (Stoddart and Smith, 1955). For this reason it is possible to determine some order of preference simply by comparing Figs. 9 and 10. Differences in preference ratings between study areas may be a result of sampling error but are more probably a result of different soil conditions, past utilization, current moisture conditions, and any other environmental factors which affect the palatability of plants (Stoddart and Smith, 1955).

Table 10. Preference order of plants common to study areas.

Order of Preference	Mount Hamell	Pinto Creek
1	Saskatoon berry	Saskatoon berry
2	Silver - berry	Silver - berry
3	Alder	Willow
4	Aspen	Aspen
5	Wild raspberry	Alder
6	Rose	Rose
7	Willow	Wild raspberry

Information from the line intersect phase of the line intersect - belt transect method did not allow the computing of density, percentage of available forage productions, percentage of diet or preference ratings for grasses and forbs. Because of the sparseness of these plants the size of the sample taken was not sufficiently large to yield meaningful results. Also at this time it was not possible to identify most species since very few seed heads and flowering parts were present. Percentage utilization was not determined since some species had developed con - siderable new growth, obliterating all evidence of past use. Since palatability changes with the seasons, and it had not been possible to sample the range in the previous fall, it was not possible to dist - inguish winter use from that which may have occurred earlier. For the above reasons, the line intersect phase was used to compare the compo - sition of winter range on both study areas on the basis of vegetative types rather than by species (Fig. 11). Had significant utilization occurred on grasses and forbs it is felt that it would have been noticed while other investigations were being carried out on the area. As such was not the case, more comprehensive studies of grass and forb utilization were presumed unwarranted.

Cowan (1944) found that shrubs and trees had a high winter palat - ability rating but that some grasses were also important throughout the year. Shaw (1958) found in Idaho that when low growing plants were covered with snow, goats utilized the available browse species, which he found to be of primary importance. In Montana, Saunders (1955) found that grasses, sedges and rushes decreased in importance with the coming of winter. Winter stomach samples contained 15.8 per cent forbs

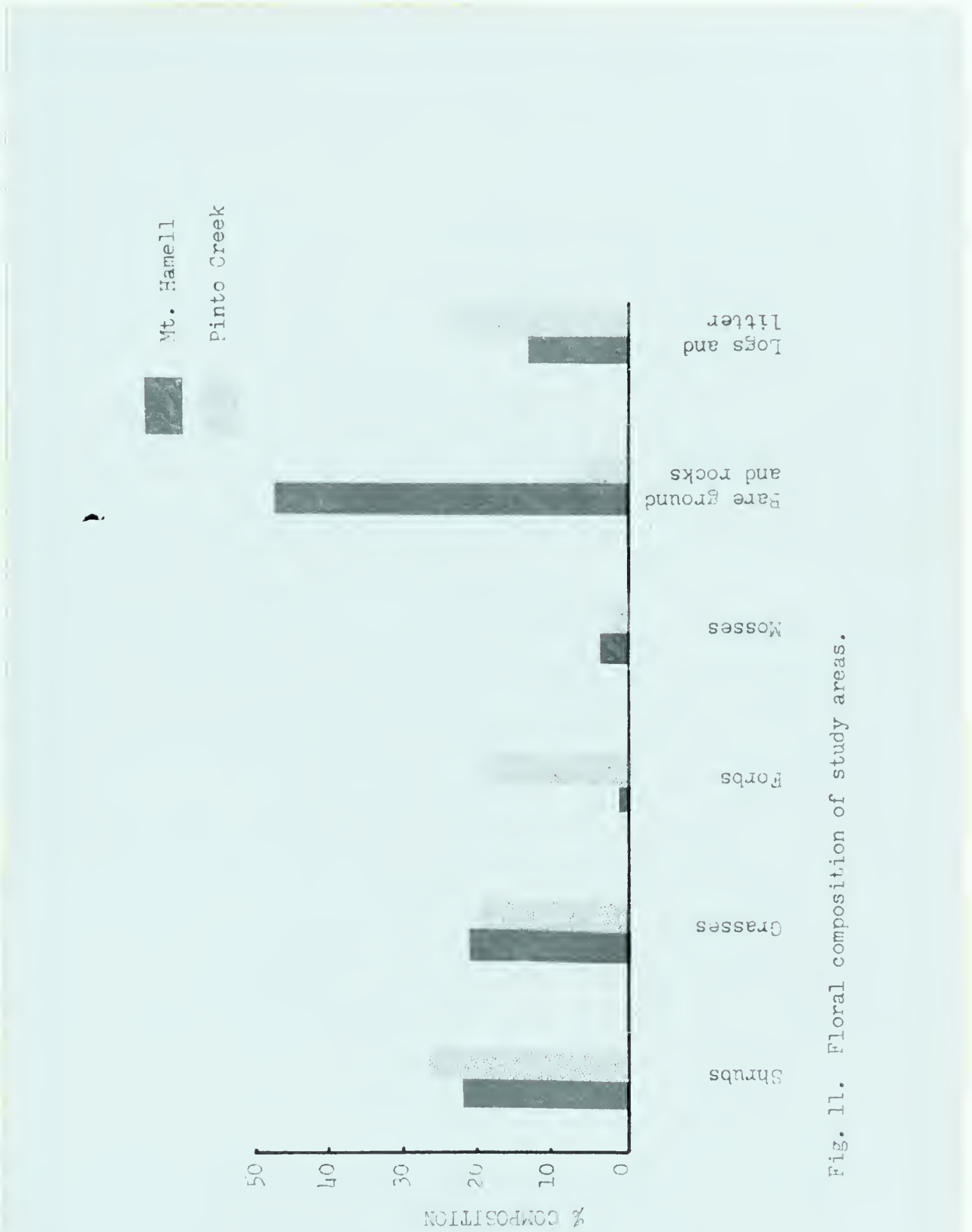

Fig. 11. Floral composition of study areas.

while shrubs, excluding coniferous trees, were an unimportant food item. Douglas fir and/or Alpine fir however, made up 24.6 to 30.4 per cent of the stomach contents thus making conifers an important winter browse. The findings of Saunders are in this respect in agreement with this study (Table 7).

Anderson (1940, in Brandborg, 1955), working in Washington; Casebeer (1948, in Brandborg, 1955), working in Montana; and Brandborg (1955), in Idaho, found that grasses constituted a major winter food item while browse species played a somewhat lesser role. Harmon (1944) and Hanson (1950, in Brandborg, 1955), working in the Black Hills, found still different food habits to exist. The Black Hills however are not within the natural range of mountain goats and are not considered to be typical goat habitat (Harmon, 1944) and will not be further discussed.

Variations in winter food habits determined by different invest - igators can very likely be explained as a result of different climatic conditions, floral compositions, depth and duration of snow cover and generally different environmental conditions under which the studied populations existed.

In view of range transects, stomach sample analysis and general reconnaissance of winter range, it can be stated with confidence that browse was the primary winter food of mountain goats in west central Alberta, with grasses, grass - like plants and forbs playing minor roles.

Late Spring, Summer and Early Fall

Some effort was made to determine spring, summer and early fall

food habits, primarily to compare with winter food studies.

Spring, summer and fall range was so extensive and consisted of so many different vegetative types that it would have been impractical to use the transect method of study. During the summer of 1962 attempts were made to determine what plants were being utilized by observing the animals feeding. In almost all instances it proved impossible to identify the plant species being utilized, even with the aid of a 25 - power spotting telescope, and for this reason the method was discon - tinued. Saunders (1955) also attempted this method but abandoned it for the same reason.

A second, similar type of study, as outlined by Brazda (1953) was then attempted, this method involving observing the animals feeding, followed by an investigation of the area grazed in an attempt to locate and record those plants utilized. This method was more successful than was the first; however, I felt the data obtained in most cases were not accurate enough to be presented in this report. Most often several hours were involved in getting to areas to be investigated and during this time so much drying had occurred that except for shrubs, it was very difficult to determine if utilization had occurred. Deter - mining utilization on alpine meadows was extremely difficult as usually no tracks were left to follow and time or date of utilization was usually impossible to determine. This method was used with some success by Saunders (1955), but was discontinued in this study in mid - summer of 1962.

Stomach samples became available from collected and hunter - killed animals throughout the course of the study, the analysis of which

appears in Table 7. Owing to the limited number of stomachs analysed I do not believe that definite conclusions should be stated here, but feel that some idea of plants used during these seasons are indicated.

HABITAT REQUIREMENTS

Location of Winter Range

During late winter and early spring of both the 1962 and 1963 general big game aerial surveys conducted throughout the Smoky River area by the Alberta Department of Lands and Forests, Fish and Wildlife Division, notes were made as to the physical features of terrain upon which goats were observed. The results of these surveys appear in Table 11. Twenty - one individual herds were observed, all of which were on south or southwest facing slopes. Of these 21 herds, 20, or 95 per cent of the herds were on wind-swept ridges free of snow or with at least a reduced snow cover, 17 herds, or 81 per cent were on range to which escape terrain in the form of cliffs was immediately available, while 16, or 76 per cent of the herds were on areas where shrubs and/or coniferous trees were present. All goats observed during the period of November through March were on ridges, except on the Pinto Creek area where no ridges occur. The Pinto Creek goat herd wintered on the highest south-facing cliffs available, where wind action is greatest, escape terrain was available and both shrubs and conifers were present. Cowan (1952) states that big game winter ranges are, "areas of low snowfall and high wind velocities, usually exposed to the south or west."

The importance of floral composition as a factor affecting the location of winter range was investigated by means of two comparisons and found to be relatively unimportant. The first comparison was be - tween two ridges, A and B, on Mount Hamell (Fig. 12) which differ chiefly in their accessibility to escape terrain. Range transects were

Table 11. Physical features which determine the location of goat winter range.

Characteristic	Proportion of herds observed
Exposure to south or southwest	100%
Snow cover absent or reduced	95%
Escape terrain available	81%
Shrubs and/or coniferous trees present	76%

Fig. 12. Mount Hamell, showing ridges A and B. Note snowpack isolating ridge A from main escape terrain in canyon.

run on both ridges using the browse circular - plot method, the results of which appear in Fig. 13. It can readily be seen that the highly pre - ferred shrubs, saskatoon berry, aspen and silver - berry, comprising a considerable amount of the winter diet of goats (Tables 8 and 9) occurred in about the same densities on both ridges. In spite of similarity in preferred shrubs, ridge A was not used by goats in winter, presumably because it was cut off from cliffs by deep snow.

The second comparison was between Mount Hamell and Pinto Creek. In this case the two ranges were occupied by goats during the winter despite marked differences in floral composition (Fig. 9), further substantiating the belief that the general floral composition does not play a major role in determining the location of winter range.

The location of wintering goat herds ranged from the mountain tops to nearly the valley floor, with most herds being found at intermediate elevations. The variation in wintering elevations indicates that elevation in itself is not a critical factor in determining winter range location.

It is concluded therefore that the four most critical factors determining the location of winter range, in order of importance, are the presence of, (1) south or southwest facing exposures; (2) ridges free of snow or with a reduced snow cover; (3) escape terrain in the form of cliffs immediately adjacent to and available to these ridges; and (4) shrubs and/or coniferous trees.

Availability of Water

It was thought that the availability and distribution of water

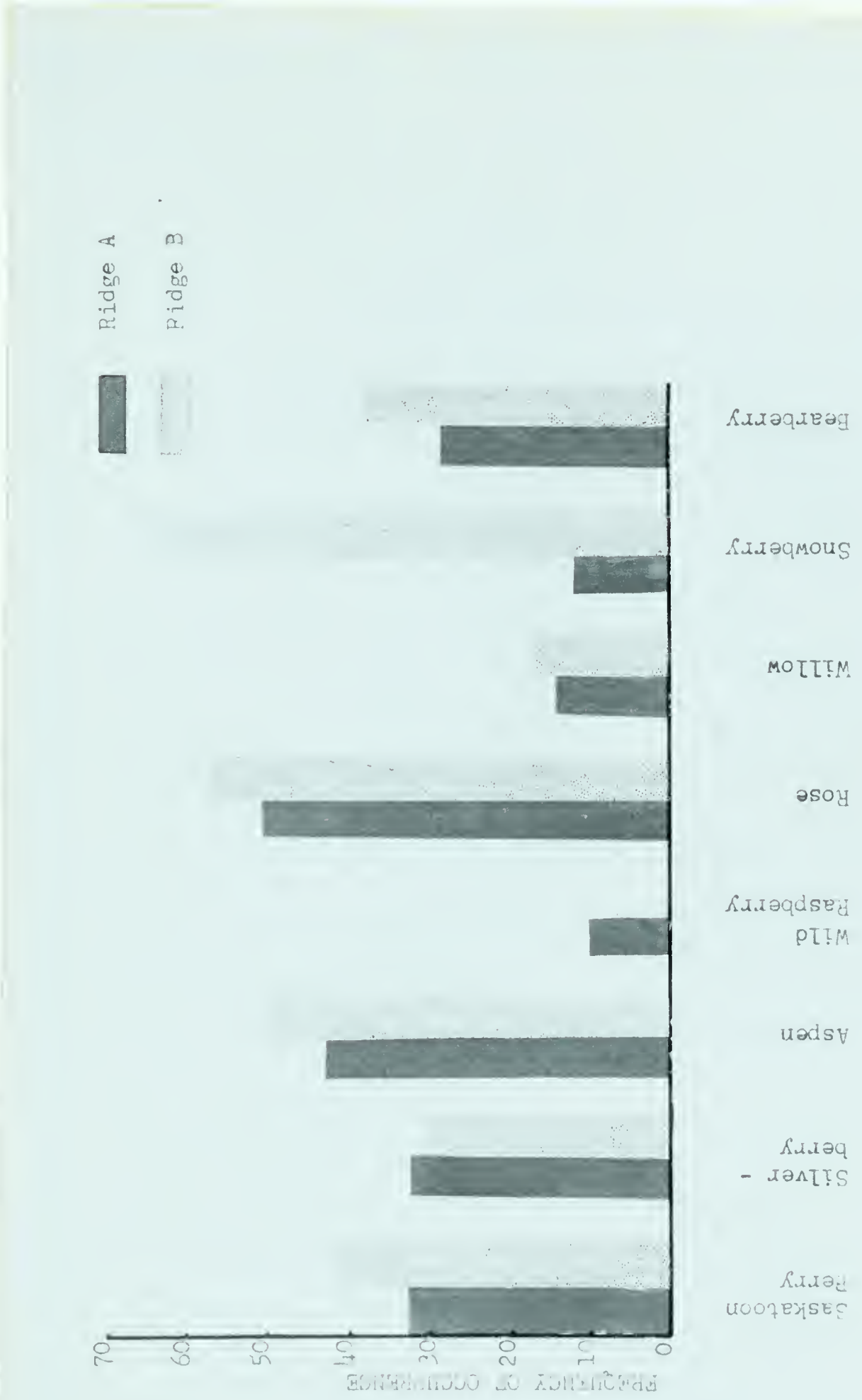

Fig. 13. Floral composition of ridges A and B, Mt. Hamell.

might affect the distribution of goats on a local basis. The water supply on both study areas was reasonably abundant and well distributed, thus making it difficult to collect information on this subject. However, some interesting observations were made.

On Mount Hamell in early August of 1962, two male goats were observed for six consecutive days on a small meadow about 2 miles from the nearest water supply. It is believed that these animals did not go to water during this entire period.

In August of 1963, one male goat was observed for four days in an area lacking in water. On the fourth day the animal was disturbed, causing it to move across the valley and bed down near a small stream about 1½ miles away. Several hours later he rose, crossed the stream without hesitating and disappeared over the mountain.

On several occasions small bands of goats were observed for as long as a week and in no case were they seen making regular trips to water, even though it was within ½ mile of them. Only one observation was made of a goat drinking and on this occasion it drank for less than 10 seconds before moving off.

In no instance was heavier grazing observed near water than on similar areas lacking in water. Anderson (1940, from Brandborg, 1955), stated that watering places were a necessary requirement of mountain goats and thought that the distribution of water affected the summer distribution of goats in Washington. Neither Brandborg (1955) nor Lentfer (1955) in Montana found water to be a factor limiting mountain goat distribution. However Brandborg and Lentfer both found mountain goats to use water more regularly than was found in this study.

It is concluded that the presence or distribution of water does not affect goat distribution on a local basis. It is also felt that goats do not require a daily or periodic supply of water, and in some cases do not take in water even when it is readily available. It appears quite possible that goats may obtain much of their moisture requirement from the vegetation they eat.

Mineral Licks

It is well known that mountain goats will travel considerable distances and through timbered valleys in order to utilize natural licks, particularly in late spring and early summer (Cowan and Brink, 1949, and Brandborg, 1955).

Two natural game licks were located in the vicinity of Mount Hamell but neither of these showed evidence of being utilized by goats. For two summers a constant vigilance was kept for a lick which was used by the Mt. Hamell goat herd, but at the end of this period it was concluded that no such lick existed. The Mt. Hamell herd appeared to be as healthy and robust as any other herd in the area which may have had a lick. No evidence was found to indicate that the absence of a lick had affected the Mt. Hamell population adversely.

It would appear that when licks are available they are quite heavily utilized by goats but they may not be a necessity except possibly where the soil is deficient in some essential elements.

Competitors for Range

Mule deer (*Odocoileus hemionus*) on Mt. Hamell and the surrounding country occupied goat winter range throughout the entire year. Deer

were out - numbered about three to one by goats on Mt. Hamell and although they wintered at a lower elevation than the goats normally did, the similar food habits of the two species could result in serious competition for food during the severe winters when goats are forced to lower elevations.

Neither moose (Alces alces) nor elk (Cervus canadensis) have been observed on Mt. Hamell. Bighorn sheep (Ovis canadensis) have been observed only rarely and in such small numbers that they cannot be con - sidered as serious competitors.

Elevation and topographical conditions on the Pinto Creek area, an atypical goat range, allowed for the possibility of a greater variety of competitors. Cast antlers of elk and moose as well as the moose themselves were seen on the Pinto Creek goat winter range, indicating that at least some of these animals spent the late winter and early spring there. Mule deer are found scattered throughout the area and undoubtedly some of them winter along the cliffs on Pinto Creek. Fortunately the mature forest surrounding Pinto Creek is not a highly productive big game area and therefore it is not likely that any competitor would occur in large enough numbers to be serious.

In my opinion the mule deer is the only potentially serious competitor for the winter food supply of goats and then only on the lower portions of goat winter range.

REPRODUCTION AND PRODUCTIVITY

Mating

Mating activities of mountain goats were not observed in this study but by knowing the approximate birth dates of the first and last kids born on Mt. Hamell for 2 consecutive years, and using a gestation period of 178 days (Brandborg, 1955), it was calculated that breeding occurred from mid - November to mid - December. This is in agreement with the mating season in Idaho and Montana (Brand - borg, 1955).

Sexual Maturity

No evidence was found in this investigation to indicate that nannies produce young earlier than their fourth spring (or at the age of 3 years).

A 36-month-old nanny collected 18 May 1962 was pregnant and approximately 2 weeks from parturition. At the time of collection she was not accompanied by a yearling, which was common among older females just prior to kidding.

A 31-month-old female collected 5 December 1963 showed one well developed corpus luteum and three developing follicles in each ovary. The animal was not lactating and was not accompanied by a kid of the previous spring.

Six mountain goat kids, four of which were from Mount Hamell, were captured in the spring of 1961 and incarcerated at the Alberta Game Farm. During that fall no evidence of rut behaviour was observed. There was evidence of breeding activity during the following mating

period of 1962 when the animals were 18 - 19 months old. Both males and females were present in the same pen, and although copulation was not observed between the captive animals, it was observed between one of the captive males and a domestic nanny. No young goats were produced in the spring of 1963. During the breeding period of 1963, with only two males and two females remaining, successful breeding did occur as a kid was born in the spring of 1964 (Oeming, personal communication). The first successful breeding occurred when the males and the females were approximately 2½ years of age, with the first kid being born on the third anniversary of the birth of the female.

It is possible that one of the sexes may have been sexually mature at an earlier age but could not reproduce because a mature animal of the other sex was not available. As already noted, the captive animals appeared to be at least as advanced physically as were goats in the wild and would, it is expected, become sexually mature equally as early. This and the above evidence indicates that at least one sex and most likely both sexes of central Alberta mountain goats do not become sexually mature until age 2½, with the first kid being produced when the parent is age 3 years.

There is some disagreement regarding the age at which mountain goats reach sexual maturity. My findings are in agreement with Brand - borg (1955) and Lentfer (1955). Lentfer examined the testes and ovaries of goats from the Crazy Mountains in Montana and stated that,"The evidence indicates first breeding at approximately 2½ years."

Swift (1940) working with an introduced goat population in the Black Hills of South Dakota stated that the first young are born when

the animal is 2 years of age. He, however, does not present any evidence in support of this statement.

Young

The birth of goat kids occurred on Mount Hamell between mid - May and the last part of June. Newborn kids, 1-day-old or less, were first observed 17 May 1962 and 16 May 1963. There was a gradual increase in the number of kids present until the latter part of June of each year. The latest observation of a newborn kid was made on 29 June 1962 and 13 June 1963.

Mid - May to late June kidding period for central Alberta agrees with the findings of Brandborg (1955) for Idaho and Montana, and Klein (1961) in Alaska, showing that the kidding period of mountain goats is similar throughout the entire north - south extent of their range. This further substantiates the argument put forth by Ransom (1964) that photoperiodism or specific light intensities and temperature gradients do not affect the time of breeding or parturition of all members of a species to the same degree over their entire range of latitude. If these two factors did affect all members to the same degree then breeding and parturition would become increasingly early with increasing latitude. As this is not the case then some factor, probably of a genetical or nutritional nature, must also be involved.

The duration of the kidding period does however appear to vary somewhat between different areas and under different conditions.

During the breeding season on Mt. Hamell prior to the spring of 1961 it was calculated that the adult (animals 2-year-old or older)

sex ratio was 22 males to 26 females, or 85:100 (Table 12). The duration of the kidding period in 1961 is unknown. During the fall of 1961 approximately 40 per cent of the Mt. Hamell herd was removed to captivity or by hunters. The following mid - winter breeding season found an adult male to female ratio of 7:17 or 41 males to 100 females. In the following spring of 1962 the kidding period extended from 17 May to 29 June. During the winter of 1962 - 63, following a light hunter kill, many young animals reached maturity and the adult sex ratio became 13 males to 23 females or 57:100. The duration of the kidding period in the spring of 1963 extended from 16 May to 13 June, a reduction of 15 days from the previous year.

Cowan (1950) working with unhunted goat populations in the Canadian National Parks found an adult sex ratio of 74 males to 100 females. This is quite near the ratio of the Mt. Hamell herd prior to its reduction in 1961. Holroyd (personal communication) observed an unhunted population at Mount Wardle (Banff National Park) and recorded the first kids on 24 May and 29 May in 1962 and 1963 respectively. The kidding period there appeared to be a sudden event, with most kids being born within 3 days after the sighting of the first kid. Brandborg (1955) observed Idaho adult sex ratios of 73 and 85 males to 100 females. He also noted, in the same populations, a kidding period from 15 May to 27 June; equally as long as the 1962 kidding period on Mt. Hamell. Anderson (1940) reported ratios of 87 and 83 males per 100 females in Washington while Hanson (1950, in Brandborg, 1955) found almost equal numbers of both sexes in the Black Hills of South Dakota.

Table 12. Summer herd structure on Mt. Hamell.

	Total herd size	Males (2 years old and older)	Females	Yearlings	Kids	Male : Female	Kids : Female
1961	80	22	26	14	18	85 : 100	68.5 : 100
1962	45	7	17	13	8	41 : 100	47.5 : 100
1963	55	13	23	7	12	57 : 100	52.1 : 100

The evidence found in my study indicates that the duration of kidding may be directly related to the existing sex ratio during the breeding season, with a decrease in the proportion of males causing a lengthening of the kidding period. However, studies elsewhere indicate that equally as long kidding periods exist in populations where the sexes occur in much more even proportions. As mentioned previously the effects of weather and animal density affect the average herd size and distribution of animals during the rut. In low density, widely distributed populations, the reduction of males would undoubt - edly allow some females to pass through several estrus cycles and perhaps the entire rut without being bred simply because of the reduced chance of their meeting with a mature male. Thus the immed - iate effect that the mid - winter sex ratio would have on the duration of kidding would be a direct result of the density and distribution of the population.

Brandborg (1955) intimates that the density and/or distribution of goats during the rut may affect breeding success. Brandborg stated, "It appears that isolation of animals on rugged ranges may affect breeding success and solitary females may occasionally pass through the entire rut without being bred."

Of 167 kid observations in the Smoky River area, no confirmed case of twinning was recorded. Twenty of these observations were made on Mt. Hamell following a 40 per cent reduction in the herd which occurred during the summer and fall of 1961. It is felt that if twin - ning were a common occurrence it would have been most evident following such a population reduction which undoubtedly reduced crowding and

increased food supply. Cheatum and Severinghaus (1950) found in New York that the incidence of pregnancy and number of embryos per female was higher among white - tailed deer on good range than it was in deer living under poorer range conditions. Lentfer (1955) also found the incidence of multiple births to be higher among goats in the Crazy Mountains on high quality virgin goat range than was found for goats on long established well utilized range on the continental divide. Gunvalson et al.(1952); Martin and Krefting (1953) reported increased productivity in deer herds following heavy harvests by hunters.

Klein (1961) reported only single births among mountain goats in Alaska. Twins were observed in Idaho and Montana (Brandborg, 1955) but their occurrence was not common. Anderson (1940) reported three sets of twins in a count of 35 kids in Washington. Seton (1927) reported a pair of twins born in Washington Zoo.

As is common with bovids generally, the incidence of multiple births in mountain goats is low. As no twins were observed in the Mount Hamell area, even after a 40 per cent reduction in herd size, it is concluded that twinning among goats in the Smoky River area is nonexistent or at least rare.

Influence of Weather

No weather recording station was located in the immediate vicinity of Mt. Hamell, the nearest being in the town of Grande Prairie about 140 miles to the north. Weather records were obtained from the towns of Grande Prairie, Edson and Jasper but no correlation in temperatures or precipitation could be made between the three stations or with the

conditions which existed at Mt. Hamell.

Local Indians and Alberta Forest Service officers considered the winter of 1960 - 61 to be average in the Smoky River area. The fol - lowing summer 18 kids were present on Mt. Hamell, producing a ratio of 18 kids to 26 females (2-year-old or older) or 68:100 (Table 12).

Local residents reported the winter of 1961 - 62 as being much more severe, with snow depths greater, temperatures colder, and more frequent thaws of short duration causing more crusting than normal. Winter kill of wild horses in the area was higher than it had been for many years and the following spring the sighting of winter killed mule deer was common. Forest officers' reports, data compiled by J. G. Stelfox (unpublished report, 1963) showed snow in the areas adjacent to the Smoky River to be from 3 to 4 feet deep and persisting from January to late March. The following spring 8 kids were born on Mount Hamell, resulting in a ratio of 8 kids to 17 females (2-year-old or older) or 47:100.

Milder weather prevailed and snow fall was less throughout the winter of 1962 - 63 (local residents). The following spring 12 kids were born, resulting in a kids to adult female ratio of 52:100 (Table 12). The apparent reproduction of 1963 was complicated by unusually heavy snow in May and early June at high elevations which may have caused increased mortality of new born kids. If these late storms had not occurred it is felt that a higher kid production would have been realized.

Cowan (1950) did not record a reduced kid crop in mountain goats following a severe winter but did find evidence of reduced fawn pro -

duction by mule deer in the mountainous regions of Alberta and British Columbia. Brandborg (1955) noted a reduced kid production following a difficult winter and stated, "In general, the data collected during this study seem to establish that production of young varies with conditions under which females winter previous to parturition,.... Adverse winter - ing conditions,... were reflected ... in lower survival and production of young."

Although the sample size is small it is apparent that the kid crop was reduced in 1962 as compared to 1961 (Table 12). This reduction may have been a direct result of the previous severe winter. Definite conclusions are complicated however, for as previously mentioned, the adult sex ratio was greatly disrupted during the breeding season prior to the 1962 kidding period and this may also have acted to reduce repro - duction. Some recovery of reproductive potential was apparently realized in 1963 but again this was complicated by adverse spring weather. Over - all winter weather conditions undoubtedly affect kid production and survival but the degree of its importance is unknown.

Little variation was noted in the survival of kids during their first winter. Of 18 kids produced in the spring of 1961, 4 were captured and removed, leaving 14 kids to enter the winter. The following spring 13 yearlings were present, indicating a 93 per cent survival of short yearlings (Table 12).

Eight kids were born the spring of 1962, 1 of which was captured and removed, leaving 7 to spend the winter. Seven yearlings were present the next spring, following a comparatively mild winter, resulting in 100 per cent survival of kids through the first winter.

Cowan (1950) found short yearling mortality to be high among mountain goats during a winter with deep snow but did not find any significant reduction in the production of young the following spring. Brandborg (1955) found both a reduction in current kid crop and a decrease in the yearling population following a heavy snow winter.

Severe weather and above normal snow depths on winter range during the winter of 1961 - 62 did not affect short yearling survival appreciably. Definite conclusions on short yearling survival are complicated by the fact that approximately 40 per cent of the Mount Hamell goat herd was removed during the fall of 1961. This drastic reduction in herd size greatly reduced crowding and competition for the existing food supply and may have made possible a higher survival of short yearlings than would otherwise have occurred.

ADVERSE FACTORS

Diseases

Of ten animals autopsied by myself throughout this study only one showed obvious signs of a disease condition. This animal appeared to have lump jaw. Cowan (1951) reported several cases of lump jaw in goats from Banff and Jasper National Parks. He attributed the cause to the fungus Actinomyces israeli.

Infections of verminous pneumonia may have been present at the site of infestation of Protostrongylus stilesi in hosts 22 and 25 (Table 11).

Ectoparasites

The two ticks Dermacentor albipictus and D. andersoni were the only ectoparasites recovered during this investigation. The presence of ticks was obvious on all goats observed from late April to mid - June. The shoulders and lower neck regions of most goats were devoid of hair as a result of the animals rubbing the tick infested areas.

A female goat collected on Mt. Hamell, 18 May, 1963, had a moderate infestation of both winter ticks (D. albipictus) and paralysis ticks (D. andersoni). A 2-year-old male collected near the same site on 6 June, 1963, had a heavy infestation of D. andersoni (Fig. 14). Tick infestations were not observed on the Pinto Creek area since this area was not visited during the period when infestations occur.

Cowan (1951) found both D. andersoni and D. albipictus on moun - tain goats while Brandborg (1955) found only D. andersoni. Both Cowan and Brandborg reported the spinose ear tick (Otobius megnini), which was not found in Alberta.

Fig. 14. Two-year-old billie showing evidence of heavy tick (D. andersoni) infestation.

It is well known that D. albipictus may be a contributing factor to the mortality of wildlife, particularly following a severe winter or period of poor food supply (Gregson, 1956). Honess and Winter (1956) stated that this parasite can cause weakness, emaciation and occasionally nervous disorders. It may also cause serious cases of anaemia. They consider D. albipictus to be the most serious pest of elk and mule deer. D. andersoni infestations are also known to be fatal to livestock through both tick paralysis and the possible spread of diseases as well as being the cause of anaemia (Jellison and Kohls, 1938; Honess and Winter, 1956). The presence of the ticks themselves constitute an annoyance and are thus an added stress.

Although no evidence of mortality directly attributed to ticks was found, the heavy infestations of both the above species may affect goat survival.

In April of 1963 the density of D. andersoni appeared to be higher on deer and goat winter range than it was elsewhere. During 10 hours of investigation on winter range on ridge B (Fig. 12), an average of 12.8 ticks per hour were removed from the clothing of both J. G. Stelfox and myself. The following day, under similar weather conditions and at the same elevations on ridge A (Fig. 12), not goat winter range, an average of 3.2 ticks per hour were removed during a similar 10 hour period. As mentioned previously and as shown in Fig. 13, the percentage composition of shrubs on both ridges was similar.

It is likely then that adult males and other goats which leave winter range in early April would have a lower infestation of D. andersoni than pregnant females and goats which remain on or near

winter range until late spring. Late spring snows at high elevations which would act to keep the animals on winter range longer than usual might also act indirectly to increase tick infestations.

Lice were not found during my investigation but the cause of death of a goat kid from Mt. Hamell, in captivity at the Alberta Game Farm, was attributed to pediculosis by the Alberta Provincial Veterinary Laboratory at Edmonton. The biting louse (Damalinia parallelus) was found on goats by Cowan (1951) and the domestic sheep louse (Linognathus pedalis) was found by Brandborg (1955).

Endoparasites

Eleven species of endoparasites were recovered from the 10 animals autopsied. These consisted of the nine nematodes Ostertagia circumcincta, O. occidentalis, O. trifurcata, Marshallagia marshalli, Teladorsagia davtiani, Nematodirus sp., Skrjabinema ovis, Protostrongylus (probably stilesi), and Trichuris sp. as well as the larval stage of Taenia hydatigena and the adult stage of the fringed tapeworm (Thysanosoma actinoides), Table 13.

Ostertagia circumcincta was recovered from seven of the ten moun - tain goats examined. O. occidentalis was recovered from six, while O. trifurcata was found in five specimens. Four of the seven hosts which harboured these stomach worm infestations were infested with all three species. These stomach worms were recovered from both the omasum and abomasum, with the abomasum being the most common site of infestation. Marshallagia marshalli was found only in the abomasum of three indi - viduals. In all cases it was found with Ostertagia and in two cases

Table 13. Helminth parasites of Alberta mountain goats.

Helminth	Host Number 1	2	3	10	11	13	14	22	23	25	Site of infestation
Ostertagia circumcincta	x	x	x	x	x	x			x		abomasum
				x							omasum
O. occidentalis	x	x			x	x					abomasum
				x							omasum
O. trifurcata	x	x				x			x		abomasum
				x							omasum
Marshallagia marshalli	x				x	x					abomasum
Teladorsagia davtiani				x					x		abomasum
Nematodirus sp.	x	x*		x	x	x			x	x?	small intestine
Skrjabinema ovis					x	x					caecum
Trichuris sp.									x*	x*	caecum
Protostrongylus ?stilesi						x?		x		x	lung parenchyma
Thysanosoma actinoides		x	x								small intestine
Taenia hydatigena (cyst)					x						mesenteries

* females only
x indicates presence of the parasite
Hosts 1, 2, 3, 11, 13, 14, 22, 25 from Mt. Hamell
Hosts 10 and 23 from Pinto Creek

it was accompanied by all three species of Ostertagia.

Teladorsagia davtiani was found in the abomasum of hosts 10 and 23 (Table 13), the only two collected from the Pinto Creek population. This helminth was not found in specimens from the Mt. Hamell area. T. davtiani has not been recorded previously from wild ungulates in North America (Becklund, 1962). The finding of this parasite in mountain goats apparently constitutes a new host record for the species (W. W. Becklund, personal communication).

Nematodirus sp. was found in six and possibly seven of the ten goats autopsied from both study areas (Table 13). It appears that these specimens may constitute a new species, to be described by W. W. Becklund.

Nematodes from the caecum of hosts 11 and 13 were identified as the pinworm Skrjabinema ovis by J. C. Holmes. Only females were found, but they agree with the characteristics given for ovis by Schad (1959).

The whipworm, Trichuris sp., probably ovis, could not be identified further as only females were recovered. This parasite occurred in only two hosts and was a minor infestation in each case.

Three goats were found to have infestations of hair lungworm (Protostrongylus sp., probably stilesi). Host number 22, about 6 weeks of age, harboured a moderately heavy and well established infestation, indicating that infestations are acquired at an early age. Forrester and Senger (1964), in Montana, found very early infestations of P. stilesi in bighorn lambs and show some evidence of infestations occur - ring before birth.

Because of my inexperience in recognizing the signs of lungworm

infestations at the beginning of the study, it is probable that infest - ations were overlooked in older animals which were the first specimens to be examined. The first infestation was detected in a young animal relatively late in the study. It also appeared that infestations were more readily observable in the lungs of younger animals.

The fringed tapeworm (Thysanosoma actinoides) was found in only two of the ten goats examined. In both cases the infestation was small.

Only one cyst of Taenia hydatigena was found throughout the investigations of mountain goats. However four cysts of T. hydatigena were recovered from a mule deer from the same range.

Except for Teladorsagia davtiani, Cowan (1951), working in Banff and Jasper National Parks, identified the same species of endoparasites in mountain goats as found in my investigations. In addition to this he found the broad tapeworm (Moniezia benedeni).

Brandborg (1955), in Idaho and Montana, found a smaller variety of parasites in mountain goats, but did however, identify several species which were not found by Cowan or myself. Those species found only by Brandborg were the lungworm (Muellerius minutissimus), and eggs from what he thought probably were the stomachworm (Trichostrongylus spp.), the tapeworms (Moniezia expansa and Thysaniezia giardi), the threadworm (Strongyloides spp.) and the liver flukes, (Dicrocoelium dendriticum and Fasciola hepatica).

Although only semi - quantitative records of parasite infesta - tions were kept, no marked difference in the degree of infestation was noted between sexes. The degree of infestation did vary with age, with kids having a much reduced parasite load. Host number 14, estimated to

be 2-weeks-old, was found to be free of parasites. Host number 22, approximately 6 weeks of age, was found to have a well established infestation of hair lungworm but was not infested with any other species. Host number 25, at approximately 3 months of age, was found to have a moderate infestation of hair lungworm and a very light infestation of both whipworms (Trichuris sp.) and Nematodirus sp. Although the sample is limited it appears that with the exception of hair lungworm, kids are relatively free of parasite infestations during the first few months. This apparent reduction of parasite infestation in kids may well be a direct result of the length of time that the animals were exposed to infestation.

The degree of infestation of all species, except lungworms, appeared to vary considerably with the seasons. Animals collected in December had fewer parasites than those collected from early spring to fall.

In general, Nematodirus sp., Skrjabinema ovis, Trichuris sp., Ostertagia spp., Marshallagia marshalli, Thysanosoma actinoides, and Taenia hydatigena (larval stage) are not thought to have serious detrimental affects on their host except in the case of heavy infesta - tions complicated by added adverse conditions (Honess and Winter, 1956; Lapage, 1959). It is not known what affect Teladorsagia davtiani has on wild ungulate hosts but it is suspected that pathogenic effects will closely resemble those of Ostertagia and Marshallagia to which it is closely related.

The hair lungworm has long been considered a serious parasite of wild and domestic animals (Honess and Winter, 1956; Forrester and Senger,

1964). Not only do these parasites cause mechanical damage to the lung tissue, rendering it non - functional, but provide conditions favorable for bacterial infections which generally result in a zone of pneumonia surrounding the parasites. Under conditions unfavorable to the host, verminous pneumonia can develop, which may result in death of the host (Honess and Winter, 1956). The decline in bighorn sheep populations in some areas of the United States in past years has been attributed to this nematode (Forrester and Senger, 1964).

No evidence of mortality directly attributed to any parasite or group of parasites was found during this investigation. Cheatum (1951) found a definite correlation between the incidence and intensity of some parasite infestations and the winter kill of deer in New York State. The fact that all goats examined over 2 weeks of age were parasitized to some degree indicates that parasites are common among goats. Heavy parasite infestations, particularly if in conjunction with other unfavorable conditions, may well be a factor contributing to the weakening and mortality of these animals.

Natural Hazards

Rock slides during spring runoff occurred with considerable frequency on Mt. Hamell. It was noted that goats avoided those areas most prone to slides during the periods of greatest slide activity. They would however, cross these areas readily if alarmed, sometimes starting small slides as a result of their own movement. On two occasions goats were observed watching rocks rolling towards them, taking shelter under nearby ledges only moments before the rocks rolled

by. It was obvious that only a second's misjudgment or a slight slow - ness in reaction time could have resulted in death.

Snowslides were rare on Mount Hamell and the surrounding area. No evidence of mortality by snowslides was found.

Cahalane (1947), Brandborg (1955), in Montana and Idaho, and Klein (1961) working in Alaska, indicate that snowslides and avalanches may be the most important single cause of mortality among mountain goats. Saunders (1955) did not find evidence to indicate that snow or rock slides were a serious mortality factor.

The occurrence of snowslides and avalanches is governed by several factors, such as depth and structure of accumulated snow, solidity of existing rock formations and steepness of slope. Therefore the importance of snowslides and avalanches will vary considerably from one locality to the next in accordance with the existing governing factors. Because of the relatively light snowfall and gentleness of slope they are not thought to be, in themselves, a serious mortality factor in the Smoky River area.

Undoubtedly goats occasionally fall to their death as a consequence of losing their footing on precipitous cliffs. During winter, when cliffs are covered with ice and snow, travel becomes more treacherous, increasing the chance of falling. Goats were observed to stumble on several occasions but always regained their balance quickly.

Nearly half of the 25 carcasses found by Brandborg (1955) were located at the base of cliffs. The fact that they were found there however, does not necessarily indicate that death was caused by falling. It is obvious that the remains of most animals which die on steep moun -

tain slopes, from any of a multitude of causes, would naturally roll to the bottom eventually. Klein (1961) considered accidents to be a relatively important cause of death.

Loss of footing on icy cliffs undoubtedly accounts for some mortality but since escape terrain utilized during winter on Mt. Hamell is usually blown free of snow it is not likely that mortality from this cause would be of a major significance.

Fighting billies, particularly during the rut, have been reported to injure their opponents fatally (Brandborg, 1955 and Geist, 1964). Active fighting is not common among goats and is therefore not likely to be a serious cause of mortality.

Predation

Of 67 coyote (Canis latrans) scats collected from Mt. Hamell during the spring of 1962 and the spring of 1963, none were found to contain goat remains. Although coyotes were common on the area throughout the summer, no observations of their interactions with goats were observed. Winter usually found the coyotes near the valley floor, well below the goat range. Brandborg (1955) and Shaw (1958), both working in Idaho, found no conclusive evidence of coyotes killing goats.

Wolves (Canis lupus) seldom occurred on Mt. Hamell, with sign being observed on only one occasion. W. Bunney, Mt. Hamell lookout man, Alberta Forest Service, observed a wolf stalking a band of females and kids during late October of 1962. A mature male, which had been grazing nearby, attacked the wolf and chased it into the timber. As mentioned previously however, wolves may have been an important factor

in the establishment of goats on the Pinto Creek study area.

Klein (1961) stated that, "during severe winters when goats are forced into deep snow at low elevations, wolves can cause severe depredations in local areas." Cowan (1947), working in Jasper and Banff National Parks, found that goats made up a very small part of the year long diet of wolves.

Bears, both grizzly (Ursus horribilis) and black did not appear to be a serious threat to goats as they did not frequently travel the same rough terrain. Occasionally bears may lie in ambush for goats which have ventured away from escape terrain (Cowan and Brink, 1949; Brandborg, 1955), nevertheless it is doubtful if a bear could out - maneuver the goats on the cliffs.

Cougars (Felis concolor) occurred only rarely on Mount Hamell and are therefore not considered to be a serious predator in that region. Brandborg (1955) and Shaw (1958) indicate that as a cougar possesses great ability to traverse rugged terrain, it could be a serious predator.

Golden eagles (Aquila chrysäetos) frequented the Mount Hamell area continuously from early April to September. Many observations were made of eagles circling goat herds which included newborn kids but on no occasion were they seen attacking them. On several instances the goats completely ignored the birds, while at other times the nannies became alarmed and the kids sought safety near their nannies' side. Eagle predation of goat kids does occur (Brandborg, 1955; Lentfer, 1955; and Shaw, 1958) but it is thought to be of little consequence on the over - all kid survival on Mount Hamell.

The degree to which any one species of carnivorous animal preys upon goats appears to be small. Cougars, wolves and eagles are probably the most potentially serious.

Malnutrition

All mountain goats examined from early July through September of each year were in good condition, having considerable amounts of reserve fat. Two animals collected in December of 1963 were also in good con - dition and showed no noticable change in body condition from those examined in the fall.

Goats observed and examined from mid - April to early June were in generally poor condition. A pregnant female collected in mid - May showed no subcutaneous fat and only minute amounts of kidney fat. Examination of a 2-year-old male, specimen number 13, collected in early June, revealed no body fat and the marrow of the long bones showed obvious signs of malnutrition.

Reconnaissance of goat winter range in the spring of 1962 and 1963 revealed no animals which had succumbed to malnutrition during the previous winter. After the spring moult however, several very thin animals were observed.

As previously noted, the kid to adult female ratio dropped following a difficult winter, presumably as a result of malnutrition of pregnant nannies. This same phenomenon was observed by Brandborg (1955). Cowan (1950) found starvation to be the prime cause of death of all big game species and indicated that malnutrition may cause reduced reproduction as well as reduced survival of young up to yearling

age. Klein (1961) indicates that starvation during heavy snow winters may be an important mortality factor.

Malnutrition was the most obvious adverse factor observed and could conceivably, in conjunction with other factors, be responsible for a substantial mortality.

Hunting

In the fall of 1960, Mount Hamell could only be reached on foot or horse - back for a distance of about 20 miles. During the hunting season of that year it was estimated that about five to six animals were shot (local residents), constituting approximately 4 per cent of the herd.

In the summer of 1961 a road was built to the Smoky River by the U. S. Steel Company which provided access by standard motor vehicles. Also during this time two roads, passable by four - wheel drive units, were constructed to the top of the mountain. During the 1961 hunting season a large number of hunters visited the area and took a minimum of 22 animals. This constituted at least a 35 per cent hunter harvest of the population.

The following year the Smoky River region was declared a Wilderness Provincial Park and the use of any motor vehicle for the purpose of hunting was banned. During that and the following fall, hunting pressure returned almost to normal with an estimated 5 to 10 per cent of the herd being taken each year. During this 4 year period, hunting pressure and the percentage of the herd harvested did not vary appreci - ably in areas where access was difficult.

It is generally agreed that goat hunting is not difficult once the hunter has reached goat habitat (Cooney, 1955; Cahalane, 1947). This is also shown by the fact that hunter success is generally high. Shaw (1958) in Idaho, found that on general hunting areas the success was 85 per cent, while Kindell (1961), also in Idaho, found a 49 per cent success. Alberta goat hunter success, as determined by a hunter questionnaire, was estimated to be approximately 40 per cent in 1962 (Wishart, unpublished report, 1964). Longhurst (1957) indicates that the average hunter harvest of goats in North America is light with an estimated 4 per cent harvest in Alberta being the heaviest.

Since hunter harvest of goats in most areas is light it is likely that this activity does not seriously affect goat populations in general. Evidence above indicates however that hunting may be a serious limiting factor in areas which are readily accessible.

Winter

Late winter to early spring is the period when the effects of all naturally occurring adverse factors are the most manifest.

No evidence of mortality directly related to disease was found. The relatively mild cases of lumpjaw and pneumonia however might easily have become fatal under the added stress of malnutrition or heavy parasite infestations.

Both species of ticks identified from Alberta mountain goats are known to cause weakness, emaciation and some mortality among wildlife (Gregson, 1956; Honess and Winter, 1956). Animals weakened from malnutrition, parasite infestations or other causes have decreased

agility and strength, thus they are prone to increased mortality from accidents, avalanches and predation. It is known that animals are more susceptible to parasite infestations when suffering from malnutrition (Lapage, 1959; Anderson, 1962).

As mentioned previously, malnutrition and resulting emaciation during the winter may cause some reproductive failure. This pos - sibility was also indicated by Brandborg (1955). Cowan (1950) con - sidered winter in general to be the most important adverse factor affecting mountain goats. Longhurst (1957) stated that the prin - cipal controls were considered to be starvation, reproductive failure and weather.

It is obvious from the above that late winter to early spring is the period when adverse factors have their most detrimental effects on mountain goats. Winter, in consort with all adverse factors related to it, appears to be the greatest enemy of goats.

SUMMARY

1. Alberta mountain goats (Oreamnos americanus americanus) had greater body measurements and body weights than did O. a. missoulae from the northwestern United States.

2. The sequence of moult of all goats was similar but there was a sufficient difference in the time of moult of adult males, sub - adults of both sexes, non - pregnant and pregnant females to allow a prediction, by the end of May, of total annual reproduction.

3. The development of annual horn rings on artificially fed known - age goats was in agreement with the horn ring age determination method established by Brandborg (1955), and thus further substantiated the belief of Cowan (1940) that annual horn rings are a result of increased sexual activity during the rut.

4. Horn length was not found to be an accurate means of age determination of mountain goats.

5. The presence, eruption and replacement of specific teeth in the lower jaw are accurate criteria for determining age to 4 years of both subspecies americanus and missoulae.

6. Mountain goats appear to possess a keen sense of sight but olfaction appears to be poorly developed.

7. The two most marked daily activities of goats were feeding and bedding.

8. The largest average monthly herd size was noted during March when snow accumulation was greatest. The lowest average monthly herd size was recorded in May, during the parturition period. Rutting behaviour also played a major role in the determination of herd sizes.

9. The two major seasonal movements were a downward movement in late fall to winter range, followed by an upward movement during spring and early summer. The spring and summer ascent appeared to be correlated with the appearance of new vegetative growth. The hori - zontal migration of goats was less than 10 miles.

10. Browse was the major food during winter while grasses and forbs played a more important role during summer. Saskatoon berry and silver - berry on the Mt. Hamell area, and rose, aspen and silver - berry on the Pinto Creek area, were the major browse species. There was some correlation of the preference rating of species common to both areas.

11. Major factors in the determination of the location of winter range were the presence of, (1) south or southwest facing exposures; (2) ridges free of snow or with a reduced snow cover; (3) escape terrain in the form of cliffs immediately adjacent to and available to these ridges; and (4) shrubs and/or coniferous trees.

12. The distribution of water did not apparently affect the distribution of goats. Goats were observed to go for long periods without drinking.

13. Mineral licks were not found to be a necessary requirement of goat range.

14. The only potentially serious competitor for goat winter range was the mule deer.

15. Mating occurred from mid - November to mid - December. Sexual maturity was reached at age $2\frac{1}{2}$ with the first young being produced when the parent was age 3 years. Kidding occurred during May and June. The duration of the kidding period may be affected by density, distribution and sex ratio of the population during the rut. Twinning was nonexistent or rare.

16. Severe winters appeared to reduce successful reproduction the following spring, however, severe winters did not appear to affect short yearling survival appreciably.

17. Two ticks, Dermacentor andersoni and D. albipictus; nine nematodes, Ostertagia circumcincta, O. occidentalis, O. trifurcata, Marshallagia marshalli, Teladorsagia davtiani, Nematodirus sp., Skrjabinema ovis, Trichuris sp., Protostrongylus sp., (probably stilesi), and two cestodes Thysanosoma actinoides and Taenia hydatigena (larval stage) were recovered from 10 mountain goats examined. No difference in degree of infestation between sexes was noted. With the exception of lungworm, kids had much lighter infestations than did animals over 1 year of age.

18. Snow and/or rockslides, accidental falls or fighting are not

thought to be, in themselves, a significant cause of mortality.

19. Cougars, wolves and eagles are thought to be the most potentially serious predators of mountain goats.

20. Malnutrition was the most obvious observable result of adverse factors.

21. Hunting was not found to be a serious cause of mortality except in a localized situation where access was easily available.

22. Winter, in consort with all related factors such as mal - nutrition, predation, accidents, avalanches and reproductive failure, appears to be the greatest enemy of goats.

LITERATURE CITED

Anderson, N. A. 1940. Mountain goat study. State of Washington Dep't. of Game Biol. Bull. 2. 21 p. (mimeo.)

Anderson, R. C. 1962. The parasites (helminths and arthropods) of white - tailed deer. Proc. Nat. Deer Dis. Symp. 1: 162 - 173.

Becklund, W. W. 1962. Distribution and hosts of the ruminant parasite Teladorsagia davtiani Andreeva and Satubaldin, 1954 (Nematoda: Trichostrongylidae) in the United States. J. Parasitol. 48: 469.

Brandborg, S. M. 1955. Life history and management of the mountain goat in Idaho. State of Idaho, Department of Fish and Game, Boise, Idaho. 142 p.

Brazda, A. R. 1953. Elk migration patterns, and some factors affecting movements in the Gallatin River drainage, Montana. J. Wildl. Mgmt. 17: 9 - 23.

Cahalane, V. H. 1947. Mammals of North America. The MacMillan Co., New York. p. 98 - 103.

Casebeer, R. L. 1948. A study of the food habits of the mountain goat (Oreamnos americanus missoulae) in western Montana. M. S. Thesis (unpubl.), Montana State Univ., Missoula, Montana.

Cheatum, E. L., and C. W. Severinghaus. 1950. Variations in fertility of white - tailed deer related to range conditions. Trans. N. Amer. Wildl. Conf. 15: 170 - 190.

Cheatum, E. L. 1951. Disease in relation to winter mortality in deer in New York. J. Wildl. Mgmt. 15: 216 - 220.

Cooney, R. F. 1955. Montana Fish and Game Commission, Wildlife Restoration Division Quarterly Report. 6(1). Jan. - April.

Cowan, I. McT. 1940. Distribution and variation in the native sheep of North America. Amer. Midland Natur., 24(3): 505 - 580.

——— . 1944. Report of wildlife studies in Jasper, Banff and Yoho National Parks in 1944 and parasites, diseases and injuries of game animals in the Rocky Mountain National Parks, 1942 - 44. Wildlife Service, Dep't. of Mines and Resources, Ottawa, Canada. 83 p. (mimeo.)

——— . 1947. The timber wolf in the Rocky Mountain National Parks of Canada. Can. J. Res. 25(D): 139 - 174.

——— . 1950. Some vital statistics of big game on overstocked mountain range. Trans. N. Amer. Wildl. Conf. 15: 581 - 588.

——— . 1951. The diseases and parasites of big game mammals of western Canada. Proc. of Fifth Ann. Game Convention. p. 37 - 64.

——— . 1952. Big game of the Mountain Province. Can. Geog. J. 44: 226 - 241.

Cowan, I. McT., and V. C. Brink. 1949. Natural game licks in the Rocky Mountain National Parks of Canada. J. Mammal. 30: 379 - 387.

Cowan, I. McT., and C. J. Guiguet. 1956. The mammals of British Columbia. Printed by Don McDiarmid, Printer to the Queen's Most Excellent Majesty, Victoria, B. C.

Forrester, D. J., and C. M. Senger. 1964. A survey of lungworm in - fection in bighorn sheep of Montana. J. Wildl. Mgmt. 28: 481 - 491.

Geist, V. 1964. On the rutting behavior of mountain goat. J. Mammal. 45: 551 - 568.

Gregson, J. D. 1956. The Ixodoidea of Canada. Science Service, Entomology Division, Canada Department of Agriculture, Pub. 930.

Gunvalson, V. E., A. B. Erickson, and D. Burcalow. 1952. Hunting season statistics as an index to range conditions and deer pop - ulation fluctuations in Minnesota. J. Wildl. Mgmt. 16: 121 - 131.

Hanson, W. M. 1950. The mountain goat of South Dakota. Ph. D. Thesis (unpubl.), Univ. of Michigan, Ann Arbor, Michigan.

Harmon, W. 1944. Notes on mountain goats in the Black Hills. J. Mammal. 25: 149 - 151.

Honess, R. F., and K. B. Winter. 1956. Diseases and parasites of wildlife in Wyoming. Wyoming Game and Fish Commission. Bull. 9. 269 p.

Jellison, W. L., and G. M. Kohls. 1938. Tick - host anemia: a secondary anemia induced by Dermacentor andersoni. Stiles. J. Parasitol. 24: 143 - 154.

Kindell, F. 1961. Idaho game population census and range study. W85 - R - 13, Job No. 6. Mt. Goat Investigations, Idaho Fish and Game Dep't.

Klein, D. B. 1961. The Alaskan mountain goat. No. 11 in the Alaska Wildl. Libr. Alaska Sportsman, March. p. 15 - 16.

Lapage, G. 1959. Veterinary helminthology and entomology. Fourth ed. The Williams and Wilkins Co., Baltimore.

Lentfer, J. W. 1955. A two year study of the rocky mountain goat in the Crazy Mountains, Montana. J. Wildl. Mgmt. 19: 417 - 429.

Longhurst, W. M. 1957. The effectiveness of hunting in controlling big game populations in North America. Trans. N. Amer. Wildl. Conf. 22: 544 - 569.

Low, A. L., and I. McT. Cowan. 1963. Age determination of deer by annular structure of dental cementum. J. Wildl. Mgmt. 27: 466 - 471.

Martin, R. F., and L. W. Krefting. 1953. The Necedah refuge deer eruption. J. Wildl. Mgmt. 17: 166 - 176.

Moss, E. H. 1955. The vegetation of Alberta. Bot. Rev. 21: 493 - 567.

——— . 1959. Flora of Alberta. University of Toronto Press. 546 p.

Ransom, A. B. 1964. Reproductive biology of white - tailed deer in Manitoba. M. Sc. Thesis (unpubl.), Univ. of Alberta, Edmonton, Alberta.

Saunders, J. K. 1955. Food habits and range use of the rocky moun - tain goat in the Crazy Mountains, Montana. J. Wildl. Mgmt. 19: 429 - 437.

Schad, G. A. 1959. A revision of the North American species of the genus Skrjabinema (Nematoda: Oxyuroidea). Proc. Helminthol. Soc. Wash. 26(2): 138 - 147.

Seton, E. T. 1927. Lives of game animals, Vol. 3. Doubleday, Foran Co., Garden City, N. Y. (Chap. LV, pp. 469 - 515).

Shaw, W. 1958. Status and hunting of mountain goats in Idaho. Idaho Wildl. Review. 11(3): 10 - 12.

Stoddart, L. A., and A. D. Smith. 1955. Range Management. American Forestry Series, Second ed. McGraw - Hill Book Company Incorporated, New York, Toronto and London. 433 p.

Swift, L. W. 1940. Rocky mountain goat in the Black Hills of South Dakota. Trans. N. Amer. Wildl. Conf. 5: 441 - 443.